University of Washington

ARBORETUM BULLETIN

Published by the Arboretum Foundation

VOL. 40
NO. 2
1977

THE ARBORETUM BULLETIN

Vol. XL, No. 2
Seattle, Wa. 1977

PRESIDENT'S MESSAGE

This letter, for me, marks the end of three years as President of the Arboretum Foundation.

While there have been many frustrations in that period, a longer-term look reveals that a number of encouraging things have been accomplished:

— The membership of the Foundation has continued to grow, exceeding the 3000 mark for the first time.

— Our financial capacity, while offset in part by inflation, has continued to increase.

— The City of Seattle and the University of Washington have come to a good working relationship in their support of the Arboretum, and are jointly undertaking the vital job of establishing long-range objectives.

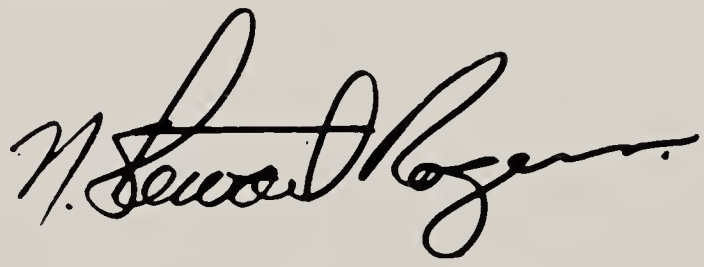
I have very much appreciated the support given by the officers, committees and staff of the Foundation. The support given in turn to the officers by the membership has been the mainspring of our ability to make progress under often difficult circumstances.

Our capacity to continue to move ahead will lie, in my opinion, in improved public communication ability in order to make better known our strengths, our wishes and the qualities of the Arboretum.

Both the City and the University are funded through the political process, and improved support of the Arboretum in that process is essential if we are to maximize the possibilities of this unique asset.

Thank you all for your help.

Sincerely,



OFFICERS

N. Stewart Rogers
President
Robert J. Behnke
1st Vice President
Mrs. Fred G. Clarke, Jr.
2nd Vice President
Mrs. John S. Robinson
3rd Vice President
Maj. Joseph W. Marshall
4th Vice President
Mrs. John A. Ogle
Secretary
Capt. Arthur P. Gardiner
Treasurer
John A. Putnam
Past President
Mrs. Marilynn R. Holm
Executive Secretary

BULLETIN EDITORIAL BOARD

Gordon D. Marckworth
Editor Emeritus

Jan Pirzio-Biroli
Editor
Nancy Ballard
Linda B. Brubaker
Mrs. Donald W. Close
Mrs. Allen B. Engle
B.J.D. Meeuse
Brian O. Mulligan
John A. Putnam
R.F. Stettler
Mrs. Casimer Vorobik
Joseph A. Witt
Curator of Plant Collections

Nancy Walz
Editorial Assistant

The ARBORETUM BULLETIN is a journal of general horticultural information published quarterly, as a bonus of membership, by the University of Washington ARBORETUM FOUNDATION, a non-profit organization to further the development of the University of Washington Arboretum. Information regarding membership in the Foundation may be obtained by writing to the ARBORETUM FOUNDATION, University of Washington, 98195 or by calling 325-4510. Articles on botany and horticulturally related subjects written by professional and amateur botanists, horticulturists, educators and gardeners are welcomed. No part of this BULLETIN may be reprinted without the authority of the ARBORETUM FOUNDATION. Lithography by Frayn Printing Company.

University of Washington
ARBORETUM BULLETIN

VOLUME 40, NUMBER 2, 1977

TABLE OF CONTENTS

President's Message	N. Stewart Rogers	Inside Front Cover
Bogs — Our Living Museums	Betty Jo Fitzgerald	2
Leaves From a Collector's Notebook: *Bursaria spinosa, Osmanthus yunnanensis*	Brian O. Mulligan	8
Mycorrhizae and Their Horticultural Importance	John Merrill and May Solomonson	11
The Canberra Botanic Gardens — A Working Institution	Roger del Moral	16
Pictures From Our Garden	Ruth Mary Close	23
Stalking Ornamental Plants in China	Mark Ravenholt	27
Announcements from the Unit Council	Ruth Mary Close	32
Notes and Comments		32
Is there a drought?	Nancy Walz	33
Book Reviews		34
Classes		35
New Members of the Arboretum Foundation		36

COVER
Open woodland,
Canberra Botanic Gardens

Photo by Roger del Moral
(See related article, p. 16)

"You pick your way via rush clumps to a rotting log." Photo: Nancy Walz

Bogs — Our Living Museums

*BETTY JO FITZGERALD**

The tranquility of the bog lake scene is broken by the rustling of a black bear stripping huckleberries. He grunts in surprise as he senses your approach and scurries off into the forest. A frog splashes in the coffee-colored water, warned by the sucking noise of the muck relinquishing its hold on your boot. You pick your way via rush clumps to a rotting log, avoiding the delicate sundews growing in the moss mat. You pause to watch the fate of a curious fly, buzzing around the glistening droplets of these intriguing plants. The creeping cranberry vines are scattered over the floating mat, which is still undulating from your passage. The sphagnum mat is a study in red and yellow-greens; it is bordered by the dark greens of the bog shrubs. The pink blooms on the bog laurel and white clusters on the Labrador tea are framed by the soft greens of the surrounding conifer woods.

The picture has been painted; the spell is cast. Bogs were traditionally the dwelling places of spirits and demons. A visit to a bog is an intriguing and enchanting experience — an awesome experience — when one realizes that a bog is a living museum, preserving the memory of those plant communities that were close upon the heels of the retreating glaciers.

Bog formation

In Washington, the Vashon glacier began to melt some 10,000 years ago. The ice sheet had reached Little Rock, a few miles south of Olympia. The legacy of the retreating glacier was a barren land with streams and rivers dammed by huge gravel deposits, dotted with potholes and undrained depressions. The migrating boreal plants tolerated cool, soggy conditions and established quickly over the Puget Sound region.

As the climate continued to warm, the boreal species were driven to higher elevations or confined in the lowland depressions and potholes. Rushes and sedges rooted in the shallower depressions and ringed the pothole lakes. The sphagnum mosses and leathery-leaved ericads,

*Betty Jo Fitzgerald wrote her Master's Thesis for the University of Washington Botany Department on the microenvironment of Kings Lake bog in western Washington. Although she completed it more than 10 years ago, she has never lost her enthusiasm for bogs. In a subsequent issue she will give us a more vivid description of Kings Lake itself.

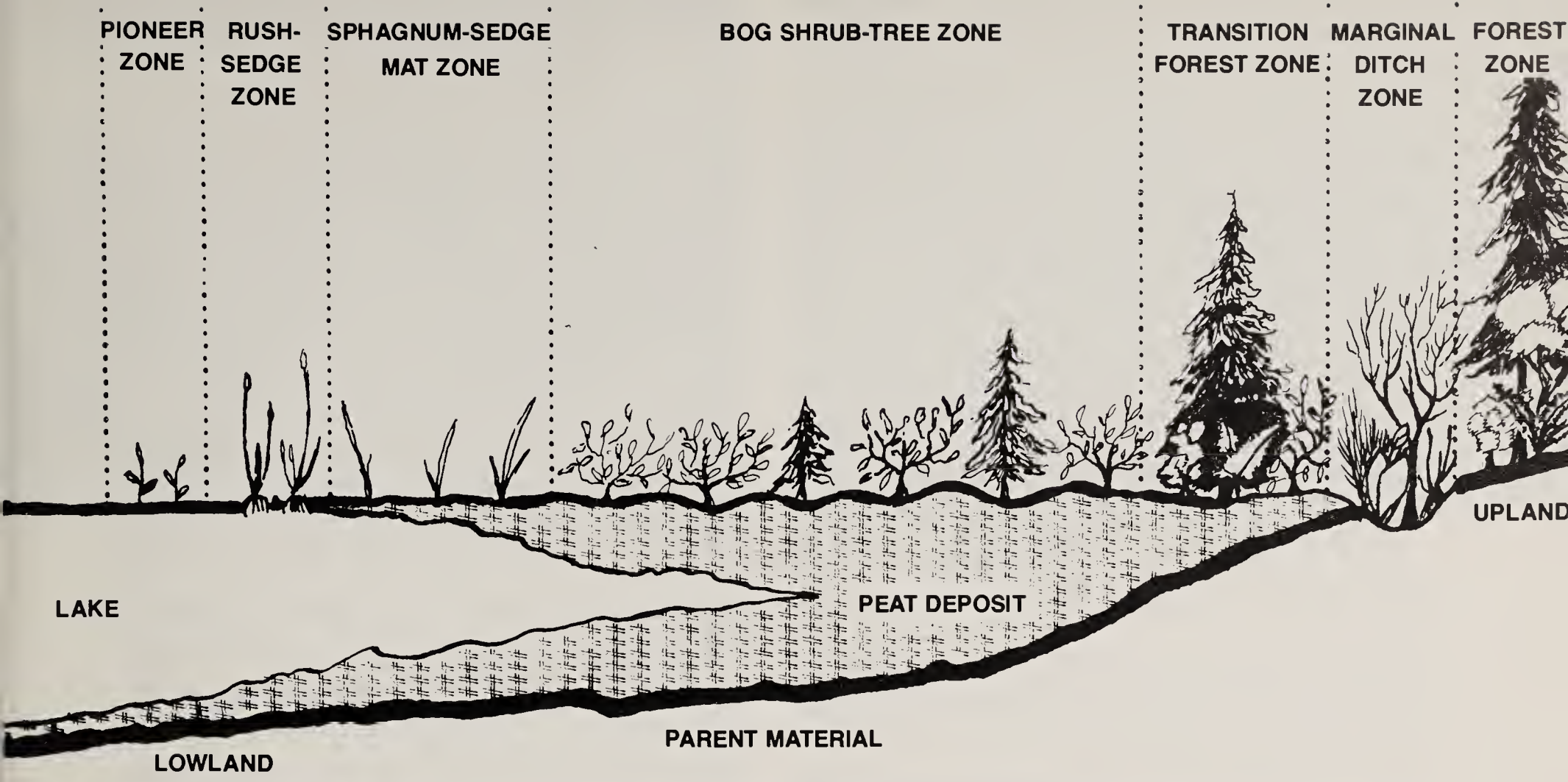


Fig. 1. Longitudinal diagram of Kings Lake bog, King County, Washington (Fitzgerald, 1966). The 2.8 acre lake is surrounded by 52 acres of peat bog. A partial list of plants found in each vegetation zone follows:

PIONEER ZONE	RUSH-SEDGE ZONE	SPHAGNUM-SEDGE MAT ZONE	BOG SHRUB-TREE ZONE	TRANSITION FOREST ZONE	MARGINAL DITCH ZONE	FOREST ZONE
green algae blue-green algae *Chara* spp. *Sphagnum* spp. sedges buckbean Labrador tea bog laurel	rushes sedges cotton grass sphagnum	sphagnum beakrush wild cranberry sundew	bog laurel Labrador tea bog rosemary western hemlock lichen sphagnum	Labrador tea western red cedar huckleberry bracken fern salal	hardhack red osier dogwood salmonberry alder cascara willow skunk cabbage	western hemlock Douglas fir vine maple salal sword fern red huckleberry twinflower

boreal relicts, established at water's edge and began to form mats over those surfaces that were not ruffled by wind and swift currents. The delicately thin mat of sphagnum was soon strengthened by the roots and rhizomes of the sedges and rushes intertwining with the woody shoots of the pioneering ericads (Fig. 1). A flexible, floating network formed, upon which sphagnum proliferated and accumulated for centuries, barring drastic environmental changes. A bog was formed.

Bog ecology

The developing mat is composed primarily of sphagnum moss, which is distinguished by its large capacity for taking in and holding water, its resistance to decay and its acidity (pH 3.5-4.8). The increasing acidity and low oxygen content of the undrained, still waters discourage bacterial life. Hence, the dead plant and animal debris does not decay as it becomes entrapped in the floating mat. The undecayed debris, called peat, contains perfectly preserved plant fragments, pollen grains and animal remains; consequently, the nutrient levels in peat are low. The stringent conditions created by the sphagnum substrate, combined with other peculiarities of the bog environment, select for a special flora (Fig. 2).

The bog matures as the remaining "eye" of the lake is closed forever by the spreading sphagnum mat. The peat eventually fills in the void between floating mat and lake bottom. Some mature bog mats support only herbs, while others support dense populations of bog shrubs. In several lo-

The texture of sphagnum moss.

Photo G. Pirzio-Biroli

Andromeda polifolia — bog rosemary
Darlingtonia californica — pitcher plant (not native to Washington, but has been transplanted)
Drosera rotundifolia and ***D. anglica*** — sundew
Eriophorum spp. — cotton grass
Habenaria spp. — bog orchid
Kalmia occidentalis and ***K. microphylla*** — bog laurel
Ledum groenlandicum — Labrador tea
Myrica gale and ***M. californica*** — sweet gale
Rynchospora alba — beakrush
Sarracenia spp. — pitcher plant (abundant in eastern bogs)
Sphagnum spp. — (12 reported in Washington)
Vaccinium oxycoccos — wild cranberry

Fig. 2. List of plants specific to boggy habitats.

cations, bog mats are invaded by neighboring conifers which coexist with the bog shrubs. Such trees are generally misshapen and stunted. The surface of the mat in the shrub-tree zone is hummocky; great clumps of lichen and other mosses mingle with the sphagnum.

The outer edge of the bog is a transition zone where bog and forest species are found growing side by side. Sphagnum is not as abundant as the forest mosses. During years of high water, spagnum, followed by other bog species, may invade and overtake the transition zone. The forest species drown and the bog plants proliferate. The snags and dead trees scattered around the edge of a bog stand as evidence for such a progression.

Most sphagnum bogs have a natural "marginal ditch" between the edge of the mat and the bordering mineral uplands. The ditch looks like a swamp. The shallow water in the ditch has a higher oxygen and mineral content than that of the bog lake. Sphagnum is usually absent in this zone where shrubs often form impenetrable thickets. A prolonged change in water table can lead to invasion of the ditch zone by bog plants.

Difference between bog, marsh and swamp

All three wetland types can occur at the same location, often merging into one another. Such intergradations confuse the casual observer trying to differentiate between bog, marsh and swamp (Fig. 3). Simply stated, a marsh is a wet prairie; a swamp is a wet prairie with shrubs and/or trees; a bog is a sphagnum cushion bearing unique herbs and shrubs, which may be interspersed with stunted conifers.

Bog terminology

A welter of terms describes various boggy types: fen, heath, muskeg, taiga, tundra, raised and blanket bogs. The first five terms describe vast expanses of country covered by organic terrain; the raised and blanket bogs refer to confined areas of organic terrain.

Fen and heath are European in origin; the former is applied to sedge- or reed-covered peatlands that are permanently flooded and the latter is dominated by ericaceous shrubs. Muskeg is an Algonquin Indian word, most properly applied to the large expanses of sphagnum peatlands in

Fig. 3. The contrasting characters of marsh, swamp and bog ecosystems (after Dansereau and Segadas-Vianna, 1952).

	MARSH	SWAMP	BOG
Water properties:			
depth	shallow		deep or shallow
drainage	allows no accumulation of organic material		blocked -– allows accumulation of organic material
color	dark green		brown/amber
pH	acid or alkaline		strongly acid
0_2 saturation	high		low
nutrients	rich		poor
micro-organisms	abundant		few
filling-in	bottom up		top and bottom
Vegetation:			
mosses	scarce or absent	scarce	abundant, mostly *Sphagnum* spp.
herbs	sedges, rushes, grasses	sedges, rushes, skunk cabbage	cotton grass, sedges, sundews, pitcher plants, orchids
shrubs	none	hardhack, willows red-osier dogwood	bog laurel, sweet gale Labrador tea, wild cranberry
trees	none	crabapple, alder cascara, cedar	hemlock, pine, cedar, spruce

Rushes and sedges growing out of the mat at water's edge. Photo: Nancy Walz

***Ledum* and *Kalmia* at the edge of the floating mat. Photo: G. Pirzio-Biroli**

Minnesota and southern Canada that bear ericaceous shrubs and stunted conifers. Taiga specifically refers to spruce- and tamarack-bearing peatlands. Tundra describes the arctic peatlands which are treeless, frozen and which bear mosses, lichens and dwarf shrubs.

A raised or ombrogenous bog *(hochmoor)* has a convex surface. The sphagnum has accumulated centrally and the plants growing within are often divorced from the water table. A raised bog receives all its water and minerals from precipitation. Rigg (1958) notes that raised bogs are common in the eastern United States, but flat bogs are characteristic in Washington. A blanket bog refers to the invading nature of sphagnum as it smothers the surrounding uplands in an unbroken mantle of peat.

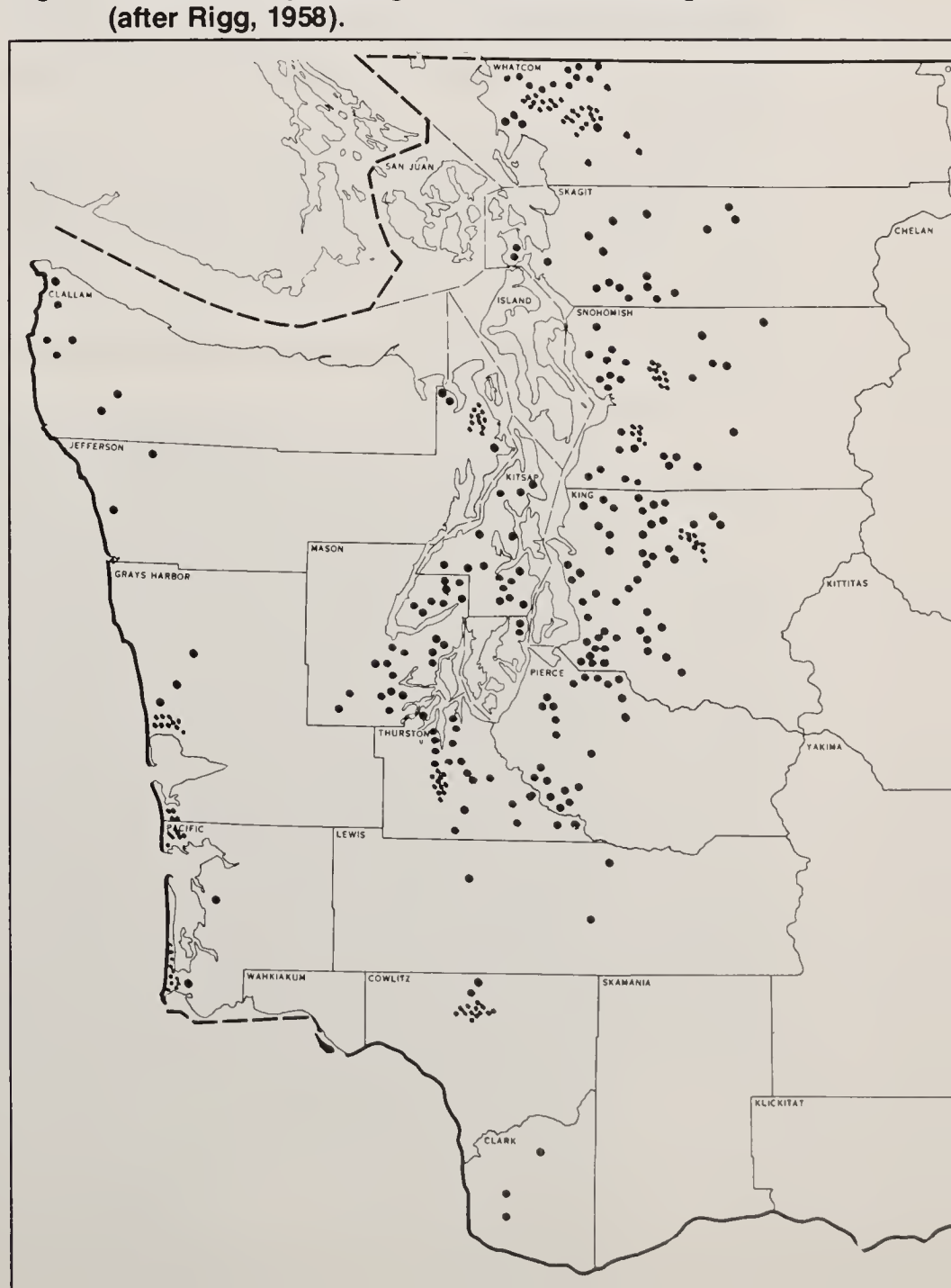
Location of Washington bogs

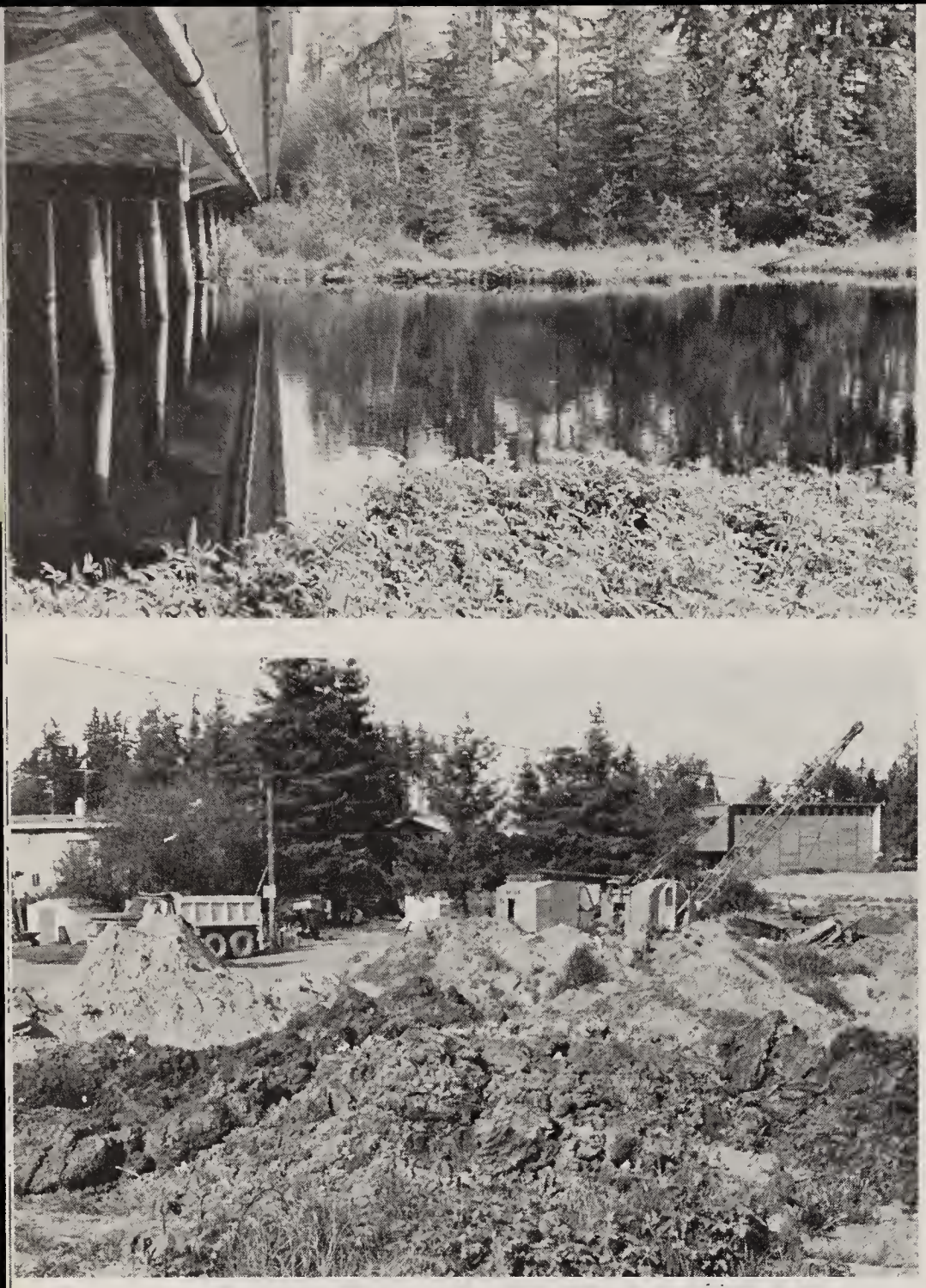
Extensive glaciation in Washington provided many opportunities for bog development. However, bogs are not limited to glaciated regions or northern climates. Peatlands are described from the southern United States and the tropics, occurring in undrained or montane situations, and then, not abundantly. In contrast, Washington contains more than 50,000 acres of peatlands, according to Rigg (1958). Twenty-eight of Washington's 39 counties support peatlands. The Puget Sound basin contains 235 peat deposits or 72% of the total peat acreage in the state (Fig. 4). Rigg (1958) and Wolcott (1961) are the best sources for locations and descriptions of Washington bogs. The numbers of unsullied peatlands have diminished over the last 25 years, but it is still possible to find and enjoy a bog.

Economic uses of peat in Washington

The demand for peat moss as a soil conditioner has increased dramatically in the Northwest. In 1959, there were 10 companies in Washington marketing high quality sphagnum peat; they provided 8% of the 419,460 tons of peat produced in the United States that year, according to a study by the Washington Department of Commerce (1961). Washington had 5 active plants in 1973 producing 21,467 tons of peat, which was about 3% of the total U.S. production, according to Mickelsen (1975). Thurston County was the largest producer of peat. Washington's 50,000 acres of peat are not considered a major resource, for they constitute less than 1% of the total peat deposits in the United States. Mickelsen (1975) states that more than one-half of the U.S. resources are in Minnesota where known deposits cover 5 million acres and have been estimated to be 7 billion tons. The United States

Fig. 4. Locations of peat bogs in western Washington (after Rigg, 1958).





The fate of one peat bog in a north Seattle neighborhood. Above: the "unsullied" portion. Below: view from the other side of the bridge. Photos: Nancy Walz

used approximately 900,000 tons of peat in 1973, producing about two-thirds of that domestically. The other one-third was imported from Canada. Because peat is a high-bulk, low-value commodity, most of Washington's peat is marketed in the Northwest.

Many of Washington's coastal bogs, constituting about 5% of total state peatlands, have been ditched and brushed for production of cranberries and blueberries. Other large areas of peatlands, especially those east of the Cascades, are used for pasturage.

Additional economic uses of peat

Peat is used in a variety of other ways: for distilling of Scotch whiskey, for filtering of industrial wastes, for treating dye-house effluents, for insulating small buildings, for packing and shipping of fresh vegetables, for germinating seeds. In Russia, milled peat is burned directly to generate electricity, providing 2% of that country's energy output. In Ireland and Finland, peat is pressed into briquets for home use; 25% of Ireland's electrical power is provided by the burning of peat. A gas company in Minnesota, according to Boffey (1975), proposes construction of a plant that converts peat into a synthetic natural gas. They claim that peat is not a fossil fuel, but a renewable natural resource, since Minnesota bogs add an equivalent of 15 million tons of dry peat each year to their surfaces. Another company proposes using the vast peatlands as energy farms, to grow burnable, renewable grasses, sedges and cattails. According to Mickelsen (1975), peat is not expected to be used as a fuel source in this country except in local areas. However, peat will be used in coastal areas as an adsorption medium in oil-spill cleanup.

Value of wetlands

Such diverse demands upon peatlands could make them an extremely limited resource in unglaciated regions. Goodwin and Niering (1975) propose preservation of all wetlands by declaring the remaining areas Registered Natural Landmarks. In their survey of potential landmark sites, the authors recommended only five wetlands[1] within Washington They would have recommended other areas, but they felt coverage of wetlands throughout the state was inadequate, particularly in the area of man's impact.

Bogs, marshes and swamps should be evaluated in other economic terms. Wetlands harbor fish and wildlife, prevent silting and flooding by acting as storage basins, absorb pollutants, provide scenes for camera and paintbrush as well as opportunities for birdwatching and botanizing. Akins (1975) describes wetlands as outdoor education exhibits and scientific laboratories; he recommends the incorporation of wetlands into any area development plan as a sound ecological use of resources.

Bogs as scientific laboratories

The characteristic appearance of bog floras has stimulated many investigations into the nature of the bog environment. (Refer to Fitzgerald, 1966, for a review of the literature.) The pH and chemical properties of peat have been well documented, but the effect of those properties on plant growth remains unknown. The extremes in bog microclimates have been recorded and examined in light of their effect on bog flora. Paleontolo-

[1]Reardon Slough, Lincoln Co.; Moxee Bog, Yakima Co.; Cedar Flats, Skammania Co.; Twelve-mile Slough, Adams Co.; Huff Lake, Pend Oreille Co.

gists use the peat profiles to confirm historical events and delineate long-range changes in climate and plant migrations. The research possibilities of the bog mystery are unlimited.

Bogs as living museums

Bogs are living records of those events and those plants that occurred in our area 10,000 years ago. Long after the performance, the changes in stage setting and floral cast lie recorded, forever, in the peat of a bog. A bog provides an excellent, as well as beautiful, setting for studying the dynamics of an ecosystem. Where else can one see plant succession in its boldest form? Be mindful of the delicate balances, tread cautiously and avail yourself of a Pacific Northwest bog.

Acknowledgement

I thank my husband, James, for his advice, encouragement and his continuing interest in bogs.

REFERENCES

Akins, Glenn J. and Carol A. Jefferson. 1975. Coastal wetlands of Oregon: a natural resource inventory report to the Oregon Conservation and Development Commission. 190 pp.

Boffey, Phillip M. 1975. Peat as fuel. Science 190:1066-70.

Dansereau, P. and F. Segadas-Vianna. 1952. Ecological study of the peat bogs of eastern North America I. Structure and evolution of vegetation. Canadian J. Bot. 30:490-520.

Deevey, E.S. 1958. Bogs. Scientific American Reprint. W.H. Freeman and Co., San Francisco, Calif. 8 pp.

Fitzgerald, Betty Jo. 1966. The microenvironment in a Pacific Northwest bog and its implications for the establishment of conifer seedlings. Unpublished M.S. thesis on file at Univ. Wash., Seattle. 164 pp.

Goodwin, Richard H. and Wm. A. Niering. 1975. Inland wetlands of the United States evaluated as potential registered natural landmarks. National Park Service, U.S. Dept. of Interior. 550 pp.

Hansen, H.P. 1947. Postglacial forest succession, climate and chronology of the Pacific Northwest. Am. Phil. Soc. Trans. 37(1):130 pp.

Mickelsen, Donald P. 1975. Peat. (section in) Mineral facts and problems. Bureau of Mines Bulletin 667:769-780. U.S. Dept. of Interior.

National Research Council, Canada. 1969. Muskeg Engineering Handbook. Ivan MacFarlane (Ed.). Univ. of Toronto Press, Toronto.

Rigg, George B. 1958. Peat resources of Washington. Division of Mines and Geology Bull. 44:272 pp.

Washington State Dept. of Commerce and Economic Development. 1961. A brief summary of the existing market for peat moss in Pacific Northwest states. Olympia, Wash. 11 pp.

Wolcott, E.E. 1961. Lakes of Washington (I). Wash. State Water Supply Bulletin #15.

"Be mindful of the delicate balances, tread cautiously and avail yourself of a Pacific Northwest bog."

Photo: G. Pirzio-Biroli

Bursaria spinosa **flowering against the south side of the Arboretum greenhouse. Photo: Brian O. Mulligan**

Leaves From a Collector's Notebook

BRIAN O. MULLIGAN

1. *Bursaria spinosa*

Few Australian shrubs or trees are to be found in the Arboretum collections excepting a few species of *Eucalyptus*. In general most Australian plants are unable to tolerate the uncertainties of our climate, particularly during the winter months and while they are still young.

One of them that has been reasonably successful is *Bursaria spinosa*, native throughout Australia, of which seeds were received from the National Botanic Garden at Canberra in February 1964. Two plants raised from this source were set out in May 1965 against the south wall of the east greenhouse. A year later ten more went to two different sites: three of these were planted on a slope with a southwestern exposure just north of Rhododendron Glen; the other seven went to the bank above the exit from the Evergreen Point Bridge, west of the Museum of History and Industry. The latter site faces almost due south and is further protected on the east by the bridge leading to the Museum.

The two plants outside the greenhouse flowered in late July and early August 1966 when less than two and one-half years old; however, one was killed to the ground by cold during the winter of 1971 and did not survive the following winter. The other plant is still with us, now seven to eight feet in height, well-branched and healthy, having both flowered and fruited in 1976. Those planted north of Rhododendron Glen failed to establish themselves for reasons unrecorded but probably due also to cold weather.

Of those placed near the Museum three were killed in the winter of 1968, and by September 1970 only two plants remained. Now eight to nine

feet tall, despite a dense growth of grass around them, these remaining plants flowered and fruited well in 1976. They are evidently well able to take care of themselves in such a position which also seems to suit some neighboring *Ceanothus – C. incanus* and the hybrid 'Olympic Lake.'

The flowers, as the photograph shows, are produced in large panicles at or near the ends of the branches, which bear some slender spines about one-half inch long that should be observed and respected. The individual flowers are small but very numerous, creamy white, sweetly scented. A mature bush in flower will make a noticeable display in midsummer when it has few competitors.

The evergreen leaves are oblanceolate, three-quarters to one and one-half inches long but only about one-quarter inch wide. They are green on the upper side but gray beneath because of a felt-like covering of hairs.

There is a second season of some interest when the plant carries a crop of small, flattened, tan-brown capsules during the fall and winter months. These are one-quarter inch wide, much like those of the common weed shepherd's purse (*Capsella bursa-pastoris*) except for their color and truncated base. The name *Bursaria* is derived from the Latin *bursa,* a pouch or purse. This genus, which is entirely Australian in origin, has only three species and is placed in the family Pittosporaceae, although it shows little resemblance to any of the commonly cultivated species of *Pittosporum,* particularly in the shape and color of both flowers and fruits. The common names used in Australia are sweet bursaria or prickly box.

For the Puget Sound area it would appear to be worth further trial on dry, sunny banks with full exposure, valuable for its late flowering season and sweet scent. Propagation either by seeds or cuttings in late summer should present no difficulties.

2. *Osmanthus yunnanensis (O. forrestii)*

In March, 1956 the Arboretum purchased from the W.B. Clarke Nursery at San Jose, California 27 kinds of young trees and shrubs, all then new to our collections. Some of these, such as the handsome holly, 'San Jose Hybrid,' *Juniperus chinensis* 'Obelisk,' *Viburnum cinnamomifolium,* and the subject of this note are still with us and have generally been successful. Others including *Azara lanceolata* from southern Chile and Argentina, the evergreen *Magnolia delavayi* from southwest China, and the elegant Mexican *Pinus patula* all succumbed to various cold winters.

Three plants of the *Osmanthus* were obtained under the name of *O. forrestii* as it was then known. One apparently failed to establish at an early age. Another was set out in February, 1961 on the east bank of Lake Washington Boulevard, nearly opposite the south gate of the Japanese garden, with other plants of the same genus; it is now eight feet high but has apparently never flowered.

The third remained in the nursery where it has reached some 10 feet in height and first bloomed in February, 1974, almost 18 years after we acquired it. This is about as long as some of the tree magnolias have taken to show their first flowers. Like other autumnal blooming species — *O. heterophyllus (O. ilicifolius)* and *O. armatus* — small clusters of three to six flowers are produced

Flowering branches of *Osmanthus yunnanensis*.

Photo: Brian O. Mulligan

in the leaf axils. They are creamy white, sweetly scented, with conspicuously reflexed petals and a pair of protruding and diverging stamens. The plant in the nursery flowered more freely in early March, 1975 and for three to four weeks from late January to mid-February, 1976 but very sparingly in February, 1977.

However, it would seem that this large shrub is perhaps of more value for its handsome evergreen foliage than for its flowering effect, even in February. On the plant in the nursery the leathery leaves measure up to 14 cm (5.5 inches) in length and 4 cm (1.5 inches) in width; they are lanceolate, acutely pointed, quite sharply toothed on young plants but entire on the upper or flowering branches of older plants. This behaviour is also frequently found in the common European holly *(Ilex aquifolium),* at least in seedling plants. Fruits have not been produced here but are described as about 12-15 mm long (0.5 inches), "deep purple with a glaucous bloom when ripe."[1] In this respect they would be similar to those of the more commonly grown *O. delavayi.*

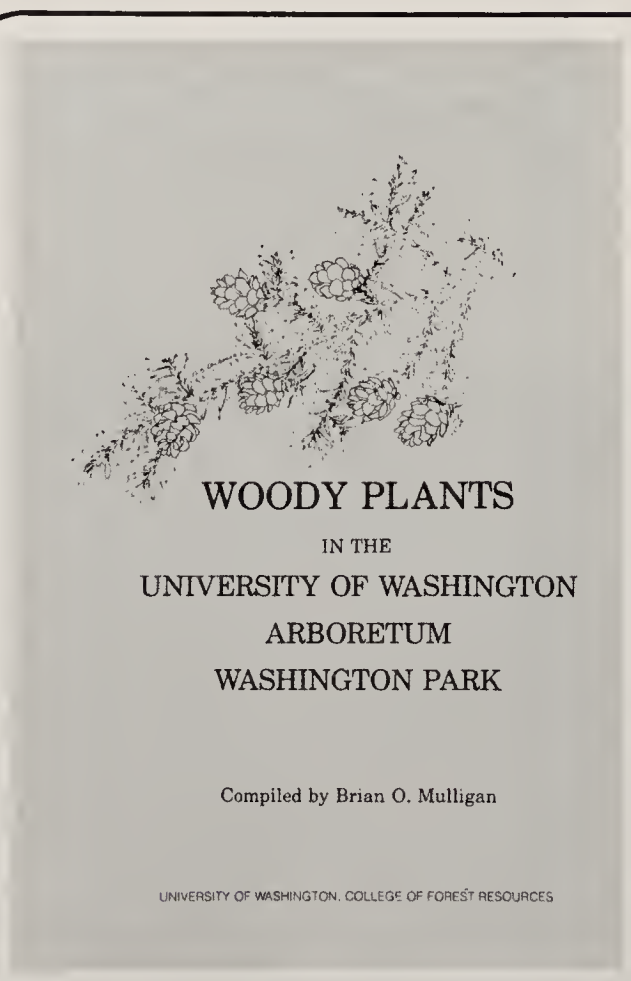
Osmanthus yunnanensis is almost confined to the province of Yunnan in southwest China, where it was first collected in May, 1884 by J.M. Delavay, a French missionary, and later by E.E. Maire, C. Schneider, J.F. Rock and more frequently by George Forrest between 1913 and 1922. There is one collection recorded by him from western Szechuan. Since field notes indicate that it may be found on dry hillsides, in thickets or in open mixed forest or sometimes beside streams, it is evidently not particular as to its habitat.

First described by Adrien Franchet in Paris, 1886 as *Pittosporum yunnanense,* it was redescribed by Alfred Rehder as *Osmanthus forrestii* in 1923 from one of Forrest's specimens collected two years earlier. But it was not until 1958 when P.S. Green[2] studied the American and Asiatic species that the earliest name given to this plant was restored to *Osmanthus,* as *O. yunnanensis* (Franchet) P.S. Green; Rehder's *O. forrestii* became its synonym.

It would appear to be quite hardy in areas around Puget Sound, but evidently needs a well-drained and sunny situation to encourage flowering. Probably a position against a wall or fence facing between south and west would be appropriate. It would be interesting to learn how other plants of this uncommon species have fared in gardens in the Pacific Coast states. One would imagine that it would enjoy the climate of southwestern Oregon and of much of coastal California south of the redwood belt. ♦

[1]P.S. Green. 1958. A monographic revision of Osmanthus in Asia and America. Notes Roy. Bot. Gdn., Edinburgh, XXII(5)495-498.

[2]Ibid.



The new catalogue is now available from the Arboretum office.
Paperback $4.50
Hardback $8.00

Mycorrhizae and Their Horticultural Importance

JOHN MERRILL and *MAY SOLOMONSON*

The Editorial Board has intended for some time to publish an article on the importance for horticulture of mycorrhizal associations. By coincidence, two students in Dr. A.R. Kruckeberg's Advanced Ornamental Botany course collaborated in the fall of 1976 on a term paper dealing with this subject. We are pleased to present it here in a condensed version, somewhat simplified for the layman.

John Merrill is a doctoral candidate in Botany at the University of Washington, having recently attained his Master's Degree in algology. May Solomonson, who graduated in the winter of 1977, is employed in a research program at the University's College of Forest Resources where she intends to enter graduate school in the fall.

Introduction

Mycorrhizae are relationships of a symbiotic nature which develop between certain fungi and the roots of many higher plants. They have great importance especially in connection with nutrient uptake and other phenomena, but they have been largely overlooked in the past by horticulturists. At the present time foresters seem to be the most knowledgeable about this phenomenon and its significance, and there is a growing interest among agriculturists. Consideration of mycorrhizae by ornamental horticulturists and landscapers, on the other hand, has been and remains almost totally lacking.

The first mention of this mycorrhizal relationship was made by Theophrastus in the third century B.C. who wrote in the *Enquiry Into Plants:* "For as for the fungi which grow from the oak roots or beside them, these occur also in other trees." Wilhelm Pfeffer in 1877 was the first to infer that mycorrhizal fungi obtain nutrient material from the soil and transfer it to the host plant which is itself incapable of otherwise obtaining such materials. He is considered by many to be the true discoverer of mycorrhizae. His paper drew little attention at the time, but in 1885 Albert Frank invented and defined the term "mycorrhiza" and stimulated the investigations of this subject which continue to the present time.

The modern concept of the mycorrhizal relationship usually considers it to be one of symbiosis or mutualism in which the two organisms coexist for mutual benefit. A slightly different approach, however, seems to more adequately encompass the facts obtained through research. Franz Meyer (1976) has described the relationship as follows:

> ". . . the fungus enters the root like a parasite in order to procure the necessary carbohydrates. Against this offense the defensive force of the tree is operating. Only when the powers of offense and defense maintain a balance can both partners live eusymbiotically with each other."

He considers the interaction to be mutual *parasitism* which reaches an equilibrium condition able to support both members' needs. The evidence which he presents involves experimental manipulations of environmental factors to favor one or the other of the partners. When, for example, the plant is given high nutrient levels, it may begin to reduce the fungus' ability to penetrate the root cortex, while on the other hand if the plant is weakened through lack of nutrients the fungal hyphae, which had previously been restricted to intercellular spaces in the cortex, may in fact begin to penetrate into the cells themselves.

Other authors have expressed the same idea. Stephen Garrett[1] describes this "uneasy-

seeming partnership" as a "stalemate between two wrestlers rather than a marriage in which husband and wife have settled into a comfortable equilibrium."

Much information has been compiled concerning the function and structure of mycorrhizae and their importance to the plant and fungal "partners." It has generally been shown that the fungal hyphae receive carbohydrates from the plant and the plants in turn obtain mineral nutrients from the fungus. There exists a broad spectrum of responses to these associations, ranging from a strictly facultative type, in which either partner may exist adequately with or without the other, to the strictly obligate associations as found in such non-green plants as certain ericoids and orchids and even some *Pinus* species which grow exceedingly poorly, if at all, without the necessary fungal infection.

Classification, Distribution and Morphology

In the plant kingdom mycorrhizae are surprisingly widespread, occurring in over 80 percent of vascular plant taxa investigated. They are distributed worldwide and are especially prominent in areas of relatively poor soil. They have traditionally been subdivided into ectomycorrhizae, in which the fungal hyphae remain intercellular, and endomycorrhizae, in which the fungal hyphae actually penetrate intracellularly.

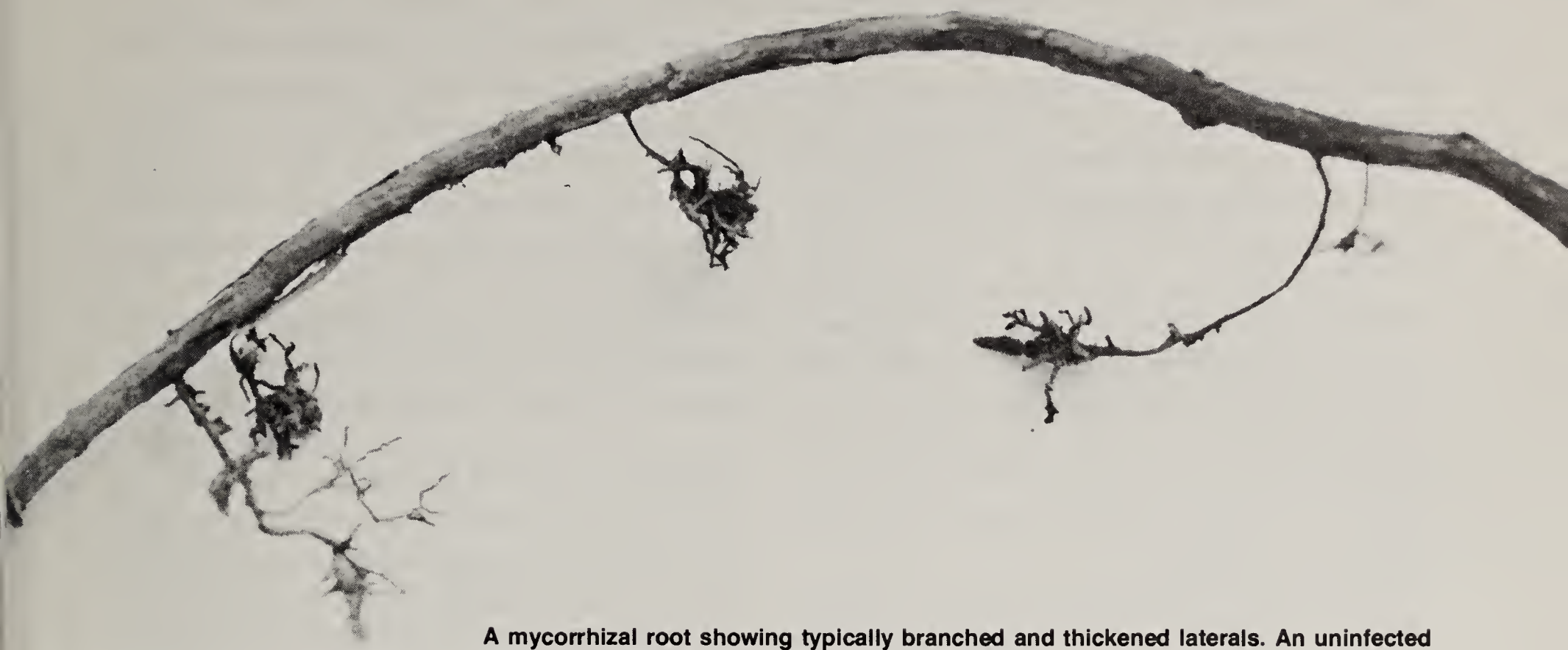
Ectomycorrhizae are generally considered most common on coniferous trees (especially in the Pinaceae) and on many angiosperm trees (notably in the Fagaceae, Rosaceae and Tiliaceae) but occur on many shrubby and herbaceous plants as well. A short list to illustrate the diversity of angiosperm host plants includes: *Acer* (maple), *Alnus* (alder), *Betula* (birch), *Carpinus, Corylus* (hazel), *Crataegus* (hawthorne), *Eucalyptus, Fraxinus* (ash), *Galium, Juglans* (walnut), *Lactuca* (lettuce), *Malus* (apple), *Nothofagus, Platanus* (plane tree), *Populus* (poplar), *Prunus* (cherries and plums), *Quercus* (oak), *Rhamnus* (buckthorn), *Ribes* (currant), *Rosa, Salix* (willow), *Sorbus* (mountain ash), *Tilia, Ulmus* (elm), *Vicia* (vetch) and *Vitis* (grape). Conifers include *Abies* (fir), *Araucaria* (monkey puzzle tree), *Cedrus* (true cedar), *Cupressus* (cypress), *Juniperus* (juniper), *Larix* (larch), *Picea* (spruce), *Pinus* (pine), *Pseudotsuga* (Douglas fir) and *Tsuga* (hemlock). The fungal associates of ectomycorrhizae are primarily Basidiomycetes which we are familiar with as mushrooms.

The morphology and anatomy of ectomycorrhizae are somewhat variable, but infected roots can usually be recognized as being shorter, of larger diameter, highly branched, lacking root hairs and by the often characteristic yellowish-brown to black color. The leader roots or mother roots of the plant will usually remain largely uninfected except for the appearance of an occasional fungal hypha on their surface.

The infected roots are usually the lateral branches and show a highly altered internal anatomy along with the external modifications described above. These roots are usually entirely enclosed within a more or less thick (1/4 to 1/3 the total thickness of the mycorrhiza) sheath of fungal hyphae called the mantle. The inner layer of the mantle is connected with a network of hyphae which penetrate between the cells of the outer layer (cortex) of the root. This network is called the "Hartig net" (after Robert Hartig, an early investigator of mycorrhizae), and it is in this area that the exchange of materials occurs between the fungus and the higher plant. On the outside of the mantle, fungal filaments (mycelia) are seen to radiate out into the soil. It is these mycelia which perform the important absorptive functions to be described in later sections.

The majority of the world's vascular plant species have *endomycorrhizae,* in which the fungal hyphae penetrate into the individual cells. So many plants have been found to develop this type of association that it has been said that a list of plants *lacking* mycorrhizae would be shorter and easier to compile than a list of plants possessing them. Of particular note however is the occurrence of this type in such important crop plants as *Citrus,* cotton, tea, tobacco, coconut palm, sugarcane, avocado, apple, cereal grasses etc., as well as in such horticulturally important genera as *Aesculus* (horsechestnut), *Araucaria* (monkey puzzle tree), *Aster, Cephalotaxus, Chamaecyparis, Coleus, Cupressus* (cypress), *Fuchsia, Ginkgo, Hedera* (ivy), *Juglans* (walnut), *Juniperus* (juniper), *Calocedrus* (incense cedar), *Liquidambar, Liriodendron* (tulip tree), *Podocarpus, Rosa, Taxus* (yew), *Thuja* and most plants in the orchid and heath families (Orchidaceae and Ericaceae). The fungal associates of endo-

[1]Garrett, S.D. 1963. Soil Fungi and Soil Fertility. MacMillan and Co. New York.



A mycorrhizal root showing typically branched and thickened laterals. An uninfected root hair appears at the far left. Photo: Nancy Walz.

mycorrhizae are primarily watermolds (Phycomycetes).

The presence of endomycorrhizal fungi within a plant root can readily be seen under a microscope; however, they do not exhibit easily visible external characters as do ectomycorrhizae.

Physiology

It should first be emphasized that to best understand the physiological relations of the fungus partner one should keep in mind the frame of reference suggested in the introduction: that the fungus is entering the root as a parasite in order to obtain the necessary carbohydrates. A balance between the attack of the fungus and the resistance of the plant results in what we recognize as a mycorrhiza. The fungus is stimulated to attack the root when there are high levels of sugars present and this attack is made easier if the plant is suffering from nutrient deficiencies.

Most of the mycorrhizal fungi have a reduced ability to break down and use the complex organic materials in the litter and soil as compared with other soil fungi. As a result they are dependent upon the host plant for energy-rich sugars. They obtain these materials by secreting large quantities of auxin (β-indolacetic acid, or IAA), a plant hormone which leads to movement of sugars toward the infected areas of the roots.

The great interest in mycorrhizae is based, however, on the simple fact that mycorrhizal plants have been shown repeatedly to grow more vigorously than non-infected plants, and this has been especially marked on poor soils. The fact that these plants can flourish on poor soils has led to the suggestion that the fungus partner increases the availability of nutrients to the plant.

The fungal mycelia which extend out from the mycorrhizal root perform functions similar to the root hairs of normal roots, except that they have a greater ability to extract nutrients and water from the soil particles to which these substances may be tightly bound. Especially important is the increased ability to take up nitrogen, phosphorus, potassium and calcium from soils from which uninfected plants could obtain little or none.

Plants with mycorrhizae have been found to be more drought-resistant than non-infected plants. This may be a result of the increased surface area generated by the fungus but is probably also a result of the far-roving external mycelia.

Mycorrhizae also benefit the plant through protection of the root from pathogenic fungi and bacteria. This protection is afforded not only by the physical barrier of the mantle, but many mycorrhizal fungi have also been shown to produce substances which specifically inhibit pathogenic competitors.

Horticultural Aspects

Since nearly all cultivated plants are potentially mycorrhizal, horticulturists should be highly interested in this mutually beneficial association between fungus and plant. In some cases, plants

cannot flourish or even survive without the fungal partner. Since the fungus aids the plant in nutrient uptake, it is possible to reduce or eliminate the addition of non-organic fertilizers. It can also help protect plants from diseases and pathogens which are always a problem in the field, garden or greenhouse.

In the greenhouse and nursery, in particular, damp-off and root-rot, caused by pathogenic fungi, are devastating diseases. The early establishment of mycorrhizae on seedlings and cuttings will inhibit these diseases, greatly reducing the losses caused by them. The increased vigor alone of a mycorrhizal plant may leave it less susceptible to attack.

The establishment of mycorrhizae may lead to reduced need for fertilizers. Ectomycorrhizal fungi absorb and store nitrogen, potassium, phosphorus and calcium, and endomycorrhizal fungi are especially important in making phosphate available. Since fertilizers are economically expensive to purchase and apply, as well as ecologically expensive because of the large amount of fossil fuels needed for their production, the use of mycorrhizae would be of great value. In addition excessive use of organic fertilizers can lead to pollution of lakes and streams when leaching and runoff take excess nutrients from the soil to waterways.

Urban and suburban landscapes often present harsh environments for plants. Frequently after excavation only the nutrient-poor subsoil remains for landscaping; the shallow soils of planting boxes common to city streets provide neither adequate nutrient levels nor moisture for plants. The increased nutrient availability and drought resistance afforded by mycorrhizae may alleviate these problems. Mycorrhizal plants are tolerant of high salts (from salting winter streets), as well as high concentrations of sulphur (from industrial pollution), high temperatures (common to all urban areas), high soil acidity and high concentrations of toxins. It should therefore be advantageous to examine the possibilities of using these highly tolerant mycorrhizal plants in the stressful environment of large cities. Many plants which have been considered not amenable to city planting might, in fact, grow quite well and flourish if inoculated with a beneficial fungus and given conditions that would stimulate the mycorrhizal association.

Mycorrhizal plants are proving useful in the reclamation of open coal mine spoils and other types of strip mines, which are generally sterile and nutrient-poor. Studies using *Pisolithus tinctorius,* an ectomycorrhizal fungus, and loblolly pine are especially promising. In particularly poor soils survival and growth over a two-year period was increased by 90 percent over non-inoculated control plants.

Other biologically sterile soils can surely benefit from the fungus-plant symbiosis. Long periods of agricultural use and consequent nutrient depletion can leave land largely unable to support good plant growth. The practice of soil fumigation with methyl bromide to kill pathogens will also kill beneficial fungal symbionts as will repeated pesticide applications. The erosion of surface soils which often follows clear-cutting of timber lands leaves behind a similarly sterile soil. Inoculation of these soils or of the seedlings with the proper mycorrhizal fungus before transplanting into these harsh environments can result in successful reforestation of otherwise impossible areas; it can save time and money in the regeneration of waste lands.

Methods of Isolation and Inoculation

Several methods of inoculation have been employed including the use of fruiting bodies (mushrooms), spores, hyphae or segments of pre-existing mycorrhizae.

If the identity of the desired fungal associate is known and if its mushrooms can be gathered, these can be distributed over the soil whole, in pieces or as a liquid slurry (after grinding with water). The germination of the spores (and possibly some of the hyphae) from these mushrooms will lead, under proper conditions, to establishment of the fungus in the soil.

If spores are available in large quantities they may first be mixed with peat-moss and vermiculite and then incorporated into the upper 10-12 cm of earth. A water suspension of spores poured over the soil seems to be a less effective inoculum. One group of workers has added spores to sterile peat-vermiculite mix and kept this moist for several months allowing the spores to colonize this substrate before it was used to inoculate the seedbeds. It is also possible to successively increase the total amount of inoculum by adding portions of this successfully colonized substrate to further quantities of sterile mix until the desired working quantity is attained.

Pre-existing mycorrhizae can be removed from a healthy plant and used to inoculate soils. The plant (preferably one of the same species intended for inoculation) can be selected from natural or cultivated conditions and segments of its mycorrhizae homogenized in a blender with water. The chopping action of the blender will not destroy the fungus as the mixture will contain numerous small pieces of intact fungal hyphae. The resulting slurry can then be poured over the soils; the intact pieces of hyphae will lead to colonization.

On a smaller scale, inoculation can be as simple as collecting forest litter or mulch from a healthy forest and spreading it on the garden (probably an adequate method for the home gardener). The mulch will contain spores and mycelia of mycorrhizal fungi (as well as saprophytic fungi and soil microorganisms which are necessary for the overall health of the soil and plants).

The isolation and maintenance of pure fungal culture may be desired in certain instances such as large-scale inoculation programs. Isolation and culture of the fungus from a mycorrhiza segment would begin with surface sterilization of the root in a solution of dilute chlorox for about 20 minutes. The root would then be aseptically cut into smaller segments and placed on sterile culture medium (corn meal agar, potato dextrose agar or similar nutrient agar). In a few days a halo of fungal hyphae radiating from the root piece would be visible. Since this usually results in a mixed, impure culture, hyphal tips from the very edge of the halo pattern should be further isolated. To inoculate plants, the agar with the fungal mycelium growing on it can simply be ground with water and this suspension poured over the soil.

Besides inoculating soils, seeds and seedlings may be inoculated directly. Before planting, the seeds can be dusted with spores or dipped in a mushroom or hyphal slurry. The spores or hyphae will then be available to germinate in synchrony with the seeds resulting in an early establishment of the mycorrhizal relationship as well as protecting the young seedlings from disease. The roots of young seedlings, perhaps at the time of transplantation from the seedbed, may also be dipped directly into a spore suspension yielding a high level of infection.

And finally, as professional and amateur gardeners become more aware of the importance of mycorrhizae, it is likely that packaged inoculum to be spread in the garden or on the nursery row will become commercially available.

Conclusion

The importance of mycorrhizae to many plants cannot be overemphasized. The information presented here should illustrate to the horticulturally inclined that this important plant-fungus relationship may greatly affect the success or failure of attempts to grow ornamental species. While natural soils in most areas probably contain sufficient populations of suitable fungi, those which have been disturbed by man — through excavation, agriculture or pollution — may require specific inoculation or introduction of beneficial fungal species. This man-caused soil sterility and infertility can only be expected to increase in the future; a working knowledge by horticulturists of the phenomenon of mycorrhizae may well become a necessity rather than a rarity.

SUGGESTED READING

Beattie, Daniel. 1976. A layman's introduction to mycorrhizae. USDA Southeastern Forest Experimental Station Publication, U.S. Government Printing Office, 1976-641-313/5151.

Harley, J.L. 1969. The Biology of Mycorrhiza. Hill, London. 334 pp.

Meyer, Franz H. 1976. Physiology of mycorrhiza. Ann. Rev. of Pl. Physiol. 25:567-586.

Trappe, J.M. 1962. Fungus associates of ectrotrophic mycorrhizae. Bot. Rev. 28(4):539-605.

The Canberra Botanic Gardens — A Working Institution

*ROGER DEL MORAL**

Botanical gardens and arboreta are as varied as their locations. They range in scope from the Kew Gardens, England, where major, world-scale, systematic studies are carried out, to provincial parks that are no more than attractive, well-labelled collections of miscellaneous plants. The Canberra Botanic Gardens aspire towards the Kew model, with characteristically Australian differences.

I recently spent several delightful hours, on two separate occasions, examining these gardens. I believe that a description of the organization, functions and mission of this institution would be instructive to those interested in the future of the University of Washington Arboretum.

The primary goals of the Canberra Botanic Gardens are to preserve, investigate, propagate and display as large a collection of the Australian flora as possible. Climate, funds and physical space are major constraints against the full realization of these goals.

Location and Description

Canberra is the heart of the Australian Capital Territory and is a modern, well-planned city of 170,000. It is located 93 miles (150 km) inland at latitude 33°S, longitude 151°E.

The Gardens, occupying an area of 266 acres, of which 110 are fenced, are situated on the lower slope of Black Mountain. The elevation is about 2000 feet with a differential of 345 feet. It is within walking distance of the Australian National University and the Plant Industry Division of the Commonwealth Scientific and Industrial Research Organization. The site includes two deep gulleys and contains considerable microhabitat variation. It is adjacent to native bush with over 400 species of vascular plants[1] that provides a buffer against encroachments of civilization.

History

Canberra itself exists as a result of Australian federation. After 53 sites were narrowed down to the eventual townsite (none could be within 100 miles of Sydney), an international contest was held to design the Capital. Walter Burley Griffin won with a plan that included the creation of an artificial lake and a reserved site on Black Mountain for a botanic garden. Burley Griffin was a man of vision, and he was the first to suggest that Australian species be given first priority. Building of the city, followed by participation in World War II, took precedence over the development of a botanic garden.

By 1944, when Dr. Lindsey Pryor was Director of Canberra Parks and Gardens, the concept of a botanic garden for Australian natives alone had evolved. His first priority was the official establishment of a park. Over the next few years he undertook to plant many natives on the proposed site. (Dr. Pryor is a world authority on *Eucalyptus*.) A fence was erected in 1951, four years after the first tree was formally planted.

By 1960, a professional staff was being recruited, but the Gardens were not opened to the public until 1966. By this time, Pryor's early plant-

---

*Dr. del Moral is Associate Professor of Botany, University of Washington. A specialist in plant ecology, he is currently on sabbatical in Australia. We welcome this contribution about the exciting botanical garden at Canberra, and we are pleased that Dr. del Moral has promised us additional articles about the flora peculiar to this island continent.

[1]J.M. Carnahan, personal communication.

ings had matured and the Gardens had several paths and a fairly diverse collection. Since that time, the parking area has needed enlargement twice because planners have failed to correctly estimate the attraction of a garden offering nothing but native Australian plants. The Gardens were formally dedicated by the Prime Minister in 1970.

The relatively slow and methodical development of the park concept and its ultimate realization saved the Gardens from becoming, as was the design in 1915, just another "English" garden. The Canberra Botanic Gardens have become an important scientific organization. It is instructive to examine their operation and function.

Organization

Well-planned botanic gardens may be organized by taxa or by habitat preferences. Both schemes are combined in the Canberra Botanic Gardens, though the former is predominant. The combination provides both scientists and those interested in the aesthetic qualities of plants efficient access to materials of interest. The major path, about one mile long, is designed to display the most colorful and extravagant species and to include examples of most of the genera available. A second loop, attached to the first and also a mile long, traverses a newer and warmer section where many rare species have been planted. A patch of species-rich native bush is maintained in this section. In addition, there are many side paths leading to sections collected by genus or devoted to species from particular habitats.

There are over 3000 species growing in the Gardens, out of a total Australian flora of 20,000 known species. I find this to be a remarkable number for the youth and climate of these gardens. The emphasis is on woody species since they require less specialized care than annuals or suffructescent perennials. *Eucalyptus* (200 of 600 species), *Acacia* (200 of 500 species), *Melaleuca, Banksia, Leptospermum* and *Callistemon* dominate the plantings. Species from the north Queensland rain forests and from western Australia are, of course, under-represented because of the great differences in climate.

An experimental program, designed to elucidate the importance of the Australian flora to culture and commerce, was recently begun. This program involves the development of special interest walks to emphasize a particular collection of plants scattered through the Gardens. The prototype is called the Aboriginal Walk and consists of a loop with 57 specially labelled plants. In contrast to most other labels, which list only the Latin name and the region where native, these include the Aboriginal name as well. A brochure provides the scientific name, English name, Aboriginal name, its use, how to prepare the substance (usually a food, beverage, drug or medicinal treatment) and a set of literature references. This program appears to be well received and certainly enhances the interest of the Gardens.

A number of special plantings deserve mention because they demonstrate that the diversity of a garden can be considerably increased, often with a minimum financial outlay.

A "rain forest" has been created in the deeper gulley that traverses the Gardens. Epiphytic orchids and ferns and tree ferns *(Dicksonia antarctica)* abound, but there are as yet no true rain forest trees. Instead hardy, tall *Eucalyptus* from wet sclerophyll forests are used. The section is made possible with a simple mist system that operates two minutes of each seven during warm weather. Subalpine species from the nearby Snowy Mountains are planted in one area in an attempt to recreate a subalpine meadow. Species of *Celmisia* and *Olearia* are planted among

(Continued on p. 20)

Upper portion of the rain forest gulley. Photo: Roger del Moral

Plants in the Canbe

Clockwise from upper left: *Acacia obtusata,* showing phy
epiphyte; mid-portion, rain forest gulley; *Grevillea rosmar*
Roger del Moral

a Botanic Gardens

e type of "leaf"; *Callistemon citrinus;* typical rain forest
lia; Eucalyptus macroryhncha growing natively. Photos:

(Continued from p. 17)

Podocarpus lawrencei trees.

Other natural habitats include: a coastal heath with dominance shared by *Epacris, Banksia* and *Callistemon* species; a section devoted to the unique flora of the Hawkesbury Sandstone; and plants of the South Australia Stirling ranges.

Functions

The Canberra Botanic Gardens staff has grown substantially since 1966 to meet several roles.[2] It consists of 15 herbarium personnel, 16 horticulturists, 12 plant propagators and 12 working in education and administration. In addition there are 28 support personnel responsible primarily for routine maintenance of the Gardens. Many of these persons are students from the university.

Herbarium

The Gardens house a large, modern herbarium facility. Compactor style cases designed to contain 350,000 specimens, currently hold 60,000. The utilitarian arrangement is alphabetical by family. A major function of the herbarium staff is field collection, which adds over 5000 specimens each year. Coordinated with the horticultural staff, collecting trips may last several weeks. Living specimens and seed are collected and a herbarium voucher is prepared for each to form the basis of accurate identification.

A second major role of the herbarium staff is to insure that displayed plants are accurately labelled. Permanent tags are not affixed until identification is absolutely certain and has been confirmed by an appropriate expert. The plantings are periodically surveyed to be certain that each plant remains properly labelled.

Rare plants are of particular importance to the role of plant preservation. The Gardens now contain several taxa extinct or nearly so in the wild. These include *Actinotus helianthi* and *Boronia serrulata*.

Horticulture

The horticulture section is devoted to devising methods of propagating "impossible" subjects and to growing plants collected as cuttings or seeds in the field. The horticulturists maintain a large propagation house and several outplanting sites. Once a species is successfully propagated, it is introduced into the display section. Pamphlets are prepared for local gardeners providing useful information for the cultivation of native species.

The horticulture section operates under the philosophy that plants should be grown with minimum care. Thus, no fertilizers are used in propagation or in display maintenance. Display watering is automated and varies depending upon the section. Weed control is effected by chipping

[2]Curator, Dr. J.W. Wrigley; Chief Botanist, in charge of the Herbarium, Mr. A.B. Court; horticultural research, Dr. Roger Ellyard; education officer, Mr. Murray Fagg; maintenance, Mr. Richard Nipperess.

Photo: Roger del Moral

Photo: Roger del Moral

Eucalyptus platypus from west Australia showing capsules and flowers.

the prunings provided by Canberra's Park Department from four million trees planted in the Capital. A four- to nine-inch mulch is maintained on most beds to reduce evaporation, condition the soil and control weeds. It appears to be an effective method.

Cultivation is simplified by two Garden Annexes. The Australian Constitution provides that the Australian Capital Territory should have access to the sea. Thus, there is a small coastal section of the A.C.T. at Jervis Bay that contains the Naval Academy and 193 acres devoted to the propagation and growing of frost intolerant species. A second annex of 10 acres at Mt. Gingera (6000 feet) is used for alpine species.

Public Service

Though these Gardens are relatively isolated from the effects of public opinion, public service is nevertheless an important function. Three aspects can be recognized: display, education and exchange. Each service is directed towards different "customers." While each is important, they are secondary to the primary mission of the Gardens.

In addition to the display beds and ponds, in which most of the available specimens may be seen, there is a small display room devoted to providing general information and to changing displays of various botanical subjects. When I visited the Gardens, displays included an informative and well-presented discussion of the families of monocots and a large-scale model of the Gardens. Garden publications, postcards, color slides and an excellent guide book ($1.75) can be obtained. The Gardens also publish an annual full-color booklet entitled "Growing Native Plants," which costs 60 cents.

Free guided tours are provided by prior arrangement led by knowledgeable, non-professional personnel. Tours for school-children have fulfilled the chief educational role, stressing the Australian flora and ecological principles. Recently, formal classes have begun in plant propagation and fundamental botany for both school children and adults.

A fortuitous set of circumstances exists that enhances the value of the Gardens to the visitor. Because it is adjacent to native bush and fenced against foxes and dogs, bird life abounds. At least 105 species can be found in the Gardens, most of which breed there and only four of which are not native to Australia. This diversity is permitted by the taxonomic and structural complexity of the vegetation and the plentiful water.

Seed exchange is the least dramatic but one of the most important functions of any botanic garden. In the case of the Canberra Botanic Gardens, this process should more properly be called "dissemination" because, while they send out large numbers of packets, they request very few. Their list is published annually and includes over 1300 species of seeds.

Problems and Limitations

Any botanic garden is faced with a series of social, biological and financial problems.

Many visitors arrive believing they will find the traditional "English" garden it might have become. When they find no children's playground, no tea-room and no monuments or fountains, they become quite dismayed. The Gardens'

staff has mounted a substantial public relations program, particularly in the tourist literature, to emphasize that the Gardens are not intended for picnics, running, games or cycling and that they are, in fact, a working scientific organization that may be visited by the public. My impression is that the people of Canberra accept and value their Gardens for the unique, irreplaceable institution that they are.

Biological problems include animals, pathogens and the ability of plants to adapt to climate. Fencing has eliminated most problems associated with large browsing animals and predators (also vandals), though an occasional wallaby or wombat makes its way in. These are invited to depart since they have no sense of respect for the flora. Native echidnas and possums exist and do not present much problem. The careful way in which plants are introduced to the display areas has minimized pathogens. I saw very little evidence of diseased or unhealthy specimens. Many of the eucalypts are nibbled substantially by insects, but this appears not to hamper their vigor and is less intense "predation" than would occur in the native bush.

The climate poses the major impediment to the successful growth of many species. Though most inhabitants of the Pacific Northwest would envy the warm spring and fall, winters bring hard frosts (to −7°C) and the summers can be very hot. Tropical plants are precluded by the winters and many alpine plants by the summer heat. The Annexes provide a partial solution to this problem, but the staff continues to look for ways in which these interesting components of the Australian flora can be displayed in the central Gardens.

Financial problems exist even in this "darling" of the national capital. While funding for staff and modern facilities has been generous for the past ten years, recent national economic problems have forced major budget cuts; the current annual budget is $640,000 Aust. The effect is to reduce the number and extent of collection trips and to slow the rate at which new species are added to the collection.

Summary

The garden at Canberra is the star of Australian botanic gardens. It successfully displays the native flora for the public because *a)* the *primary* mission is to preserve the Australian flora, *b)* the Gardens are not intended to provide recreation in the usual sense, *c)* there is strict physical control of the land that permits intensive and accurate labels and *d)* the level of support is adequate to maintain the grounds, collect new material and propagate existing material.

The Australian National University uses the Gardens heavily in both taxonomic and ecological courses. The sections arranged by habitats are particularly valuable. The Arboretum in Seattle would be enhanced by the creation of small habitat localities for Washington plant communities. Special interest trails could easily be created, demonstrating, for example, edible plants or plants of anthropological interest.

The Australian general public has only recently realized that they are the stewards of absolutely unique flora, fauna and ecosystems. Acts of environmental degradation that once passed unnoticed now feed the fires of controversy. The future of wood chipping, clear-felling and park creation are debated hotly in Parliament and on the street. The Canberra Botanic Gardens that began as a few pen marks on Burley Griffin's successful plan for a national capital has become a major national resource for the study and preservation of an endangered flora. ▲

Angiosanthus flavidus **Photo: Roger del Moral**

Pictures From Our Garden

Photo: Nancy Walz

Birch at the water's edge in spring.

One day about six months ago, when the Editorial Board was discussing the kinds of articles that our readers might most enjoy, Ruth Mary Close remarked that she was always interested in new ideas for plant combinations. And on that statement is based the concept for a continuing series to replace "Some of Our Favorites." This much-loved column dates back more than 15 years, but, as Brian Mulligan suggests, "We are running out of favorites."

The garden of Mr. and Mrs. Donald W. Close is one of the most beautiful in the Seattle area, and Ruth Mary Close is one of our most skillful gardeners. It is fitting, therefore, that she should introduce this new series with the following account of those plant combinations that she has found to be especially pleasing.

We hope that her vignettes will inspire our readers to share with us their own preferred combinations, garden scenes or even successful uses of individual plants. In this manner gardeners will have the opportunity to participate in the Bulletin *at the same time that others can enjoy their contributions.*

Thank you, Ruth Mary Close, not only for suggesting the subject of this proposed series, but also for helping to launch it with your wonderful descriptions of pictures from your garden. EDITOR

Gertrude Jekyll, writing in England at the turn of the century, promoted the idea that gardens should be planted to provide a series of pictures, one merging into another, creating a harmonious whole with something of interest at each season.

In today's garden, if we are interested in landscape design, and not just in collecting plants, we try to accomplish the same thing. The colorful herbaceous border has given way to a more naturalistic use of trees and evergreen shrubs, with broad patches of groundcover linking them together. The challenge for us is to select plants that will be at home in our setting at the same time that we arrange them into a succession of pleasing pictures. There is such a wealth of material available in the Northwest that no two gardens could ever be the same. The following are some pictures from our own garden that we have enjoyed.

Winter vistas, seen from the shelter of the

house, are favorites. From our dining room window the white bark of a clump of European birch *(Betula pendula)* silhouetted against the lake catches the least bit of winter sun. Its hanging purplish-brown branchlets dance in the wind. A spreading mugho pine *(Pinus mugo)* and a large rock add stability to the scene. Daffodils give color in the spring followed later by two blue forms of Siberian iris.

Against tall western red cedars, the brilliant *Elaeagnus pungens* 'Maculata,' its green leaves splashed with gold, attracts attention from the kitchen.

The shell pink flowers of *Camellia sasanqua* 'Jean May' frame the bedroom window in December and January. Espaliered against a south wall, its glossy foliage complements the dark, deeply veined leaves and pinkish-red buds of *Viburnum davidii.* Overhead, the pale pink blossoms of an autumn cherry (*Prunus subhirtella* 'Autumnalis') open whenever the weather warms.

Across the walk, *Erica herbacea (carnea)* 'King George' with its rich pink flowers rambles at the base and in the cracks of moss-covered rocks. Beyond, *Mahonia nervosa,* its shiny green leaves tinged with purple by early frosts, and the bold pattern of a mugho pine are a foil for the lavender flowers of the early *Rhododendron mucronulatum.*

On a difficult slope on the north side of the house, under a tall Douglas fir, a *Fatsia japonica* with its large, tropical, fan-shaped leaves enjoys the shade and abundant room to grow as it pleases. The green bark of a clump of vine maple *(Acer circinatum)* is conspicuous in winter, while the leaves provide exciting color in the fall as they turn to yellow and orange-scarlet. The ground, covered with a solid mat of English ivy *(Hedera helix),* completes a simple planting requiring a minimum amount of care and water.

Pieris japonica in the foundation planting also on the north side of the house is beautiful at all times of year, but never more attractive than when its buds begin to open above the elegant chartreuse blooms and lush foliage of *Helleborus lividus corsicus.* The low creeping *Pachysandra terminalis* fills the spaces between. We look forward to the fragrant winter blooms of *Sarcococca humilis* which has recently been added.

Winter would not be complete without the yellow spidery flowers of the 20-foot tall witch hazel *(Hamamelis mollis)* blooming in January, outlined against a Douglas fir with salal *(Gaultheria shallon)* at its base. This is a colorful sight again in autumn when the leaves turn to bright gold. Planted at one end of the paddle tennis court near the driveway, its perfume is a special bonus for early morning joggers.

Another treat is *Jasminum nudiflorum* trained up and over the six-foot high fence; its star-laden branches cascade to the floor of the court. The bright yellow blossoms continue to open for several dark months.

A light and airy corner finds *Pieris japonica* 'Variegata,' its small leaves edged in creamy white, growing against an old cedar stump with a carpet of *Erica herbacea (carnea)* 'Springwood White' at its base and salal in the background. The dainty lemony blossoms of the *Cornus mas* overhead lift one's spirits when they open in February and March.

Probably the most spectacular picture in our garden is a Mt. Fuji cherry (*Prunus serrulata* 'Shirotae') planted 25 years ago at the edge of the patio, now stretching its vigorous horizontal branches for 65 feet across the front of the house.

The "difficult slope" — Douglas fir, *Fatsia* with vine maple in the background. Photo: Nancy Walz

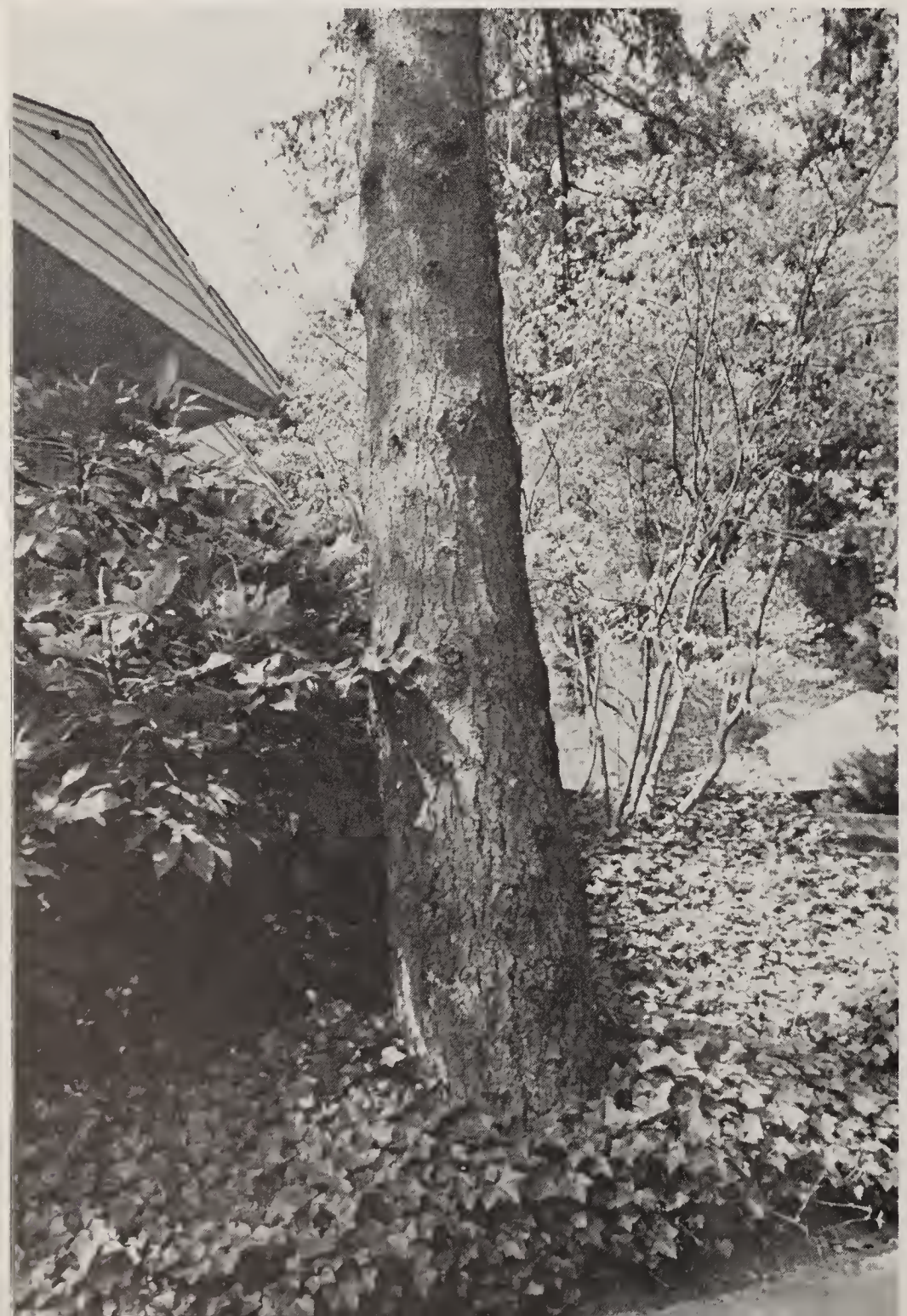


Photo: G. Pirzio-Biroli

In April — the Mt. Fuji cherry from the lawn.

Although its double white blossoms are breath-taking against the blue sky, they are even prettier spotlighted at night. A highlight of April is our Mt. Fuji dinner when guests wear Japanese kimonas and dine on Japanese food in honor of this beauty. *Mahonia aquifolium* provides a mass of yellow flowers underneath. This requires considerable pruning to keep it from getting too tall, but offers an ever ready supply of greens for the house.

A *Magnolia soulangiana* 'Rustica Rubra' is trained against the two-story, used-brick wall on the east side of the house where its large leaves and sturdy branches seem to be in scale with the location. The furry buds unfold into large cup-shaped flowers, purplish-red outside and white within. It has never required watering, and a minumum amount of pruning keeps it in shape.

Like soft pink clouds, the blossoms of *Prunus yedoensis* 'Akebono' form a canopy for the dainty pink royal azalea *Rhododendron schlippenbachii. Epimedium pinnatum* forms the ground-cover.

At a corner of the house *Malus hupehensis,* its arching branches covered with pink blossoms, stands above *Rhododendron* 'Rosa Mundi' whose pale pink trusses blend nicely with the slightly deeper mauve bloom of several *R. pemakoense.* This year *Ajuga reptans* appeared underneath with its purplish leaves and enriched the scene.

May brings such an overwhelming display of color that it is hard to define separate pictures as one blends into another in a succession of bloom. The rhododendron border planted against a background of cedar, fir and hemlock blooms in shades of pink, rose and white. Azalea 'Pinkie Pearce' and *Rhododendron mucronatum* grow in the foreground with London pride *(Saxifraga umbrosa)* tying them all together. This planting is almost as pleasing to me when the flowers are gone and the last seed pod removed, for then the different shades of green and the varying textures of the leaves become evident.

Rhododendron 'Mrs. E.C. Sterling, one of my favorites, with its lavender-pink, slightly frilled trusses, neat foliage and spreading growth habit, is planted with several *R. carolinianum* whose blooms open at the same time and are the same color. These grow beneath a katsura tree *(Cercidiphyllum japonicum)* with the lacy, gray-green needles of digger pine *(Pinus sabiniana)* in the background. The small round leaves of the katsura are reddish when they open, become a clear apple green and then turn bright yellow and apricot in the fall.

Under a Close apple, an early fruiting variety found by my folks in a nursery in Victoria, B.C., the bright pink bells of *Rhododendron* 'Bow Bells' appear with several *R.* 'Blue Diamond, *R. mucronatum* (white tinged with pink) and the low-growing white Azalea 'Helen Close.' Blue forget-me-

nots, allowed to seed themselves, and the dainty white flowers of sweet woodruff *(Asperula odorata)* add a soft touch.

The long arching branches of the *Prunus serrulata* 'Ojochin,' laden with white blossoms, reach out over *Rhododendron* 'Rainbow' whose deep pink-edged trusses open to reveal white centers. *Mahonia aquifolium* 'Compacta' and salal are planted beneath.

The creamy pink flowers of *Rhododendron hanceanum nanum,* the pink form, with its bronzy new foliage is very pleasing near *Viburnum davidii.*

At the base of a giant madrone *(Arbutus menziesii)* with its long rope swing loved by all of our children and those who visit us, sun-lovers *Photinia serrulata* and *Photinia glabra* flourish. Their bright coppery and red new foliage go well with the rose-orange and yellow *Rhododentron scyphocalyx* and the semi-double, salmon-pink Azalea macrantha *(Rhododendron indicum).* The red stems and feathery pale pink flowers of London pride link this planting to the nearby *Rhododendron* 'Dawn's Delight,' whose deep pink buds open pale pink.

In summer when activities center at the lake front, the focus of our garden is on a large bed of red and pink astilbe growing on a gentle slope in front of a clump of cedar trees at the edge of the lawn. An ample supply of mulch and water rewards us with a colorful display for a long period of time.

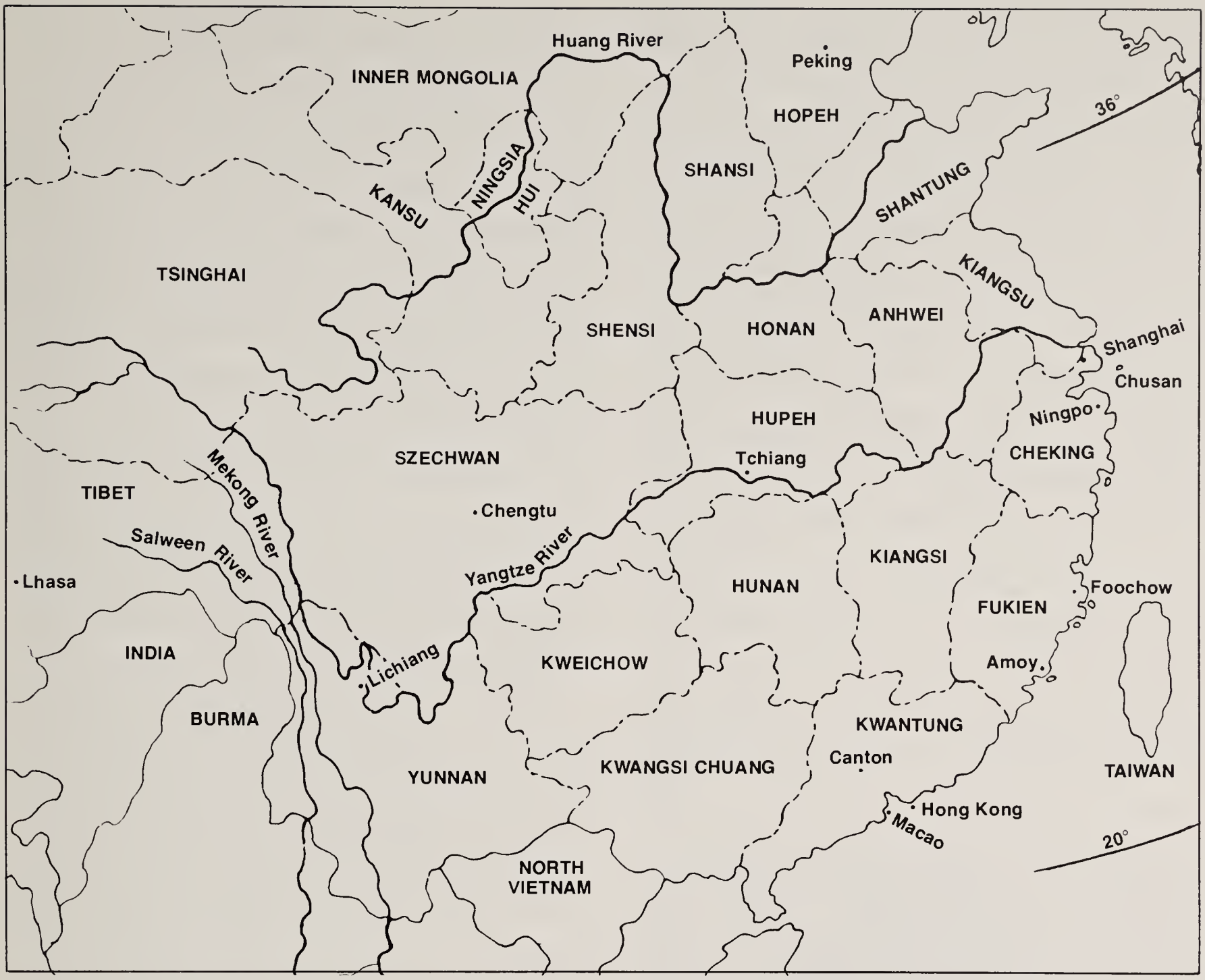
The beautifully branched *Stewartia pseudocamellia* is grown as a specimen tree. We are still waiting for its camellia-like flowers to appear, but its fiery red fall color is dazzling at the edge of the lake.

When the first of the vine maples turn to orange and gold, we know that fall is on the way. *Enkianthus campanulatus, Oxydendrum arboreum, Euonymus alatus and E. sachalinensis (planipes),* azaleas and blueberries all turn shades of red in a colorful bed.

Not all of our plantings have been successful, and not all plants happy where we thought they should grow. New species have been added. Others, grown from cutting and seed, are not yet big enough to be a part of the picture. A garden is a vital changing creation; painting with "living color" is a challenge. *RUTH MARY CLOSE*

In shades of purple, moisture-loving *Primula denticulata* at the base of a moss-covered rock; *P. auriculata* enjoying the well-drained pocket above.

Photo: Nancy Walz



Stalking Ornamental Plants in China

*MARK RAVENHOLT**

During the tertiary era of geologic time the climate of the northern hemisphere was often considerably milder than that of today. The present arctic zone was mainly ice-free; the land connections around the globe were continuous and covered with vast forests. According to Ernest Wilson in his book *Aristocrats of the Trees,* the types of tree vegetation were similar throughout the northern hemisphere. "Doubtless, then as now, species had a limited distribution but the genera then, much more so than today, were widespread. Tulip-trees, Magnolias, Sweet Gums, Ginkgos, Sassafras, Sequoias, and, indeed, countless others grew in Europe, in America, and in Asia."

Then came the ice ages. Land connections between America and Asia were severed. In America the ice advanced south of Philadelphia destroying all vegetation in its path. Europe's flora was pushed to the shores of the Mediterranean. China and Japan survived the glacial period almost unscathed and, "The net result is that the existing flora of the Chinese Empire

*Mark Ravenholt was another student in Dr. Kruckeberg's Advanced Ornamental Botany course (cf. preceding article on mycorrhizae p. 11) whose term paper the Editorial Board has deemed suitable for publication in the *Bulletin*. We hope that it will encourage more of our readers to delve further into the fascinating literature surrounding plant exploration.

and of central Japan southward is really a miniature of the whole flora of the northern hemisphere in pre-glacial times. In China and in the parts of Japan indicated grow today many peculiar types, and all the principal genera of trees known from the other parts of the northern hemisphere except *Robinia, Laburnum, Platanus,* true Cedars *(Cedrus), Sequoia* and *Taxodium;* and of the latter two there are such very closely allied trees as *Taiwania* and *Glyptostrobus*. Fossils of many types which grow in the Orient today occur in Europe, and recent dredgings off the Dutch-English coast have added much to prove that the ancient flora of Europe was similar to that now flourishing in the Far East." (Wilson, 1930.)

From its sea-borne discovery by Portugal in 1516 until the middle 1800's, China effectively guarded most of its rich cultural heritage and unique flora from occidental intrusion and exploration. The Chinese were so confident of their cultural and military superiority over all foreigners that they shunned diplomatic and economic associations and remained inside their own self-sufficient cocoon. Since the days of Marco Polo the wealth of China had been legendary and Europeans had been eager to establish trade relations. China resisted by restricting trade to the ports of Canton and Macao and, with few exceptions, travel within the interior was strictly forbidden.

Jesuit missionaries managed some meager penetration into the interior among whom Pierre Nicholas le Cheron D'Incarville stands out as the first trained botanist to collect plants and seeds in China with the intention of enhancing European ornamental gardens. D'Incarville did most of his collecting near Peking; his most important introduction was *Ailanthus altissima,* the tree-of-heaven.

Chrysanthemums and camellias were common florist flowers in Canton and Macao. When some of these began to appear in the British Isles, interest in Chinese plants expanded. In the early 19th century with the rising influence of the Horticultural Society, founded in 1804, British interest in ornamental gardening boomed. Hothouse plants were the rage, and a new breed of wealthy gardeners emerged. Rivalries evolved bent on establishing superior exotic gardens. To increase the prestige and loveliness of their gardens individuals commissioned East India Company captains to purchase Chinese plants.

Inevitably the first professional plant collector, in the person of William Kerr, arrived in Canton in 1803 under the sponsorship of the Royal Gardens at Kew. His salary of 100 pounds per annum was insufficient to allow Kerr to make himself presentable for the high Chinese authorities in order to plea for a visa to explore the interior. Hence most of his introductions were taxa that were common in Canton nursery gardens: *Kerria japonica, Nandina domestica, Lonicera japonica* var. *flexuosa, Rosa banksiae* and *Nymphaea pygmaea*.

Since Canton and Macao lie on the tropical and subtropical sourthern coast of China, the indigenous flora is, mostly, unsuitable for the cold winters of the British Isles and other temperate environments. The collecting of plants suitable for these climates is our concern here; therefore a brief geographical sketch of China is in order.

The northern coastal provinces are temperate but have a rather uninteresting flora. Inside these perimeter provinces is a belt always straining to feed the bulk of the huge Chinese population; millenia of civilization have denuded the countryside of much of its non-agricultural vegetation. " . . . the lower hills and plains of North China are formed of loess. This is the fine dust of Central Asia deposited during countless years into layers varying from a few inches to hundreds of feet in thickness. This loess bakes hard in the summer and turns into a particularly unpleasant glue-like clay in the rains. It cannot be expected to carry an interesting flora." (Cox, 1945.)

It is the provinces of Szechwan, Yunnan, Shensi, Kansu, Hupeh and the southeastern part of Tibet where most of the choice ornamentals have been discovered. This area, possessing great variety of relief, rainfall and vegetation, is transected by five mighty rivers: the Yangtze, Salween, Mekong, Hwang Ho (Yellow) and Tsangpo (Brahmaputra). Mountains rise to 23,000 feet in northwest Szechwan, and parts of Yunnan get 50 inches of rain each year. This is spectacular country — a dramatic setting for the trials and tribulations of plant hunting.

The Opium War between China and Britain ended with the treaty of Nanking in 1842. Hong Kong island was ceded to Britain, and four new treaty ports were opened: Amoy, Foochow, Ning-po and Shanghai; foreigners were allowed fairly free movement within 40 to 50 miles of the ports.

Robert Fortune (1812-1880)[1]

Enter the prodigious plant explorer and collector Robert Fortune. Trained at the Royal Botanic Gardens at Edinburgh under William McNabb, he was chosen in 1843 by the Horticultural Society (later the R.H.S.) to be their collector in China. "The general objects of your mission are, 1st, to collect seeds and plants of an ornamental or useful kind, not already cultivated in Great Britain, and, 2nd, to obtain information upon Chinese gardening and agriculture together with the nature of the climate and its apparent influence on vegetation." Particularly he was asked to hunt for, among other items:

"The Peaches of Pekin, cultivated in the Emperor's garden and weighing 2 lbs.
The plants that yield tea of different qualities.
The circumstances under which the Enkianthi grow at Hong Kong, where they are found wild in the mountains.
The Plant which furnishes Rice Paper.
Peonies with blue flowers, the existence of which is, however, doubtful.
Camellias with yellow flowers, if such exist.
The true Mandarin Orange called Song-pee-leen.
The orange called Cum-quat.
The Lilies of Fokien, eaten as Chestnuts when boiled.
Tree and herbaceous Peonies.
The varieties of Bamboo and the uses to which they are applied."

At the time of Fortune's first expedition the interior of China remained a mystery to Europeans. The Chinese of that period were a sedentary people who rarely traveled outside their own town or province and who called traveling "eating bitterness." (Farrer, 1917.) Hence they were themselves relatively ignorant of the interior. Fortune visited all the treaty ports and the island of Chusan near Ning-po on his first expedition, collecting from private and nursery gardens and, also, from the perimeter areas of the ports. In the hills above Ning-po he managed to study critically the Chinese tea-growing agriculture. His most important introductions from this first trip were: *Anemone hupehensis* var. *elegans, Weigela florida (rosea), Dicentra spectabilis, Platycodon grandiflorus, Forsythia viridissima, Trachycarpus fortunei, Ilex cornuta, Cryptomeria japonica, Rhododendron* (Azalea) *obtusum* and the two early-flowering climbers *Lonicera fragrantissima* and *Jasminum nudiflorum*.

Fortune returned to Britain in 1846 and held the position of Curator of the Chelsea Physics Garden for a short while before the East India

[1]Unless otherwise noted, the quotations in this section have been taken from E.H.M. Cox's *Plant Hunting in China*.

Photos: Nancy Walz

***Sciadopitys verticillata*, the umbrella pine. Far right: almost 50 years old. Inset: close-up of the leaf pattern.**

Company commissioned him to return to China in order to secure tea plants *(Camellia sinensis)* for cultivation in India. Because the Chinese were zealously secretive of their tea horticulture and manufacture, Fortune disguised himself as a Chinese native to procure seeds and learn more of the curing process. He discovered that green and black tea originated from the same species, the curing process being responsible for the different flavors and colors. This second trip was also a great success. "In February, 1851, he himself sailed for Calcutta with 2000 young tea plants, 17,000 germinated seedlings and six expert Tea makers." *Berberis (mahonia) bealei* and *Chamaecyparis funebris* were important introductions from this trip.

Fortune's third and fourth expeditions were less productive than the first two, yet he collected more tea plants, *Sciadopitys verticillata* (the umbrella pine), *Osmanthus heterophyllus (ilicifolius)* and *Primula japonica*. "I shall never forget the morning on which a basketful of this charming plant was first brought to my door. Its flowers of a rich magenta colour, were arranged in tiers, one above another, on a spike nearly two feet in height. It was beyond all question the most beautiful species of the genus to which it belongs, and will, I doubt not, henceforth take its place as the 'Queen of the Primroses.' "

Fortune was a cool-headed collector as witnessed by the manner in which he repulsed a pirate attack on the junk he was traveling home upon with his collection from the first expedition. The passengers and most of the crew on Fortune's junk had scrambled below decks at the first sighting of the pirates — to hide their valuables and pray for salvation. Fortune was ill at the time but hardly one to risk his entire collection and, more important, his life without a game fight. As the pirate boat bore down on them he raised himself above the high stern of the junk and, "while the pirates were not more than twenty yards away from us, hooting and yelling, I raked their decks fore and aft, with shot and ball from my double-barrelled gun. Had a thunderbolt fallen amongst them, they could not have been more surprized." (Healey, 1975.) After 19 years of exploration, Fortune returned to England in 1862 and spent the rest of his life as a farmer and antique dealer.

Much of Fortune's success with plant introductions was due to the high percentage of plants that survived the long sea voyage back to Britain. In the expeditions of his predecessors, storms, over- and under-watering, salt spray and general neglect had all contributed to a poor percentage of survivors. One of the reasons so many of Fortune's plants survived was that he was the first major collector to use Wardian cases. These cases were the invention of Dr. Nathaniel Ward, a London physician, who had noticed in 1829 the peculiar longevity of a fern growing in a lid-covered wide-mouthed jar. "In 1833 Dr. Ward decided to go on from there and had two cases modelled on the principle of the bottle, but shaped like the old plant cabins, with all glass sides and tops, suitably strengthened at the corners and edges, and as hermetically sealed as the manufacturers could make them — in other words a miniature, nearly air-sealed greenhouse!" (Lemmon, 1968.)

French and Russian explorers of the mid-19th century

Jean Pierre Armand David was a French missionary sent to China primarily to convert the infidels, but he was also an able natural scientist proficient in both botany and zoology. Soon after his arrival in China, David was much more taken with the unique flora and fauna of the country than with the plight of the barbarous infidels and rationalized his switch of emphasis to natural sciences: "But all sciences concerned with the works of creation increase the glory of their creator, for to know truth is to know God . . ." (Cox, 1945.)

David made three major exploring trips: the first to the deserts of Mongolia, the second to the eastern border area of Tibet (the most productive of the three botanically), and the third to various central Chinese provinces. On the second trip while climbing Hongshantin mountain he came across *Davidia involucrata,* the beautiful dove or pocket handkerchief tree, with its distinctive large white bracts. He was also the first European to see the handsome Panda bear, "My Christian hunters . . . bring me a young white bear, which they took alive but unfortunately killed in order to carry it more easily. The young white bear, which they sell to me very dearly, is all white except for the legs, ears, and around the eyes, which are black." (Healey, 1975.) The collections David sent back to France contained at least 2000 species including *Clematis hera clei-*

Photo: Don Normark

Meconopsis betonicifolia

folia var. *davidiana, cotoneaster salicifolia, Stransvaesia davidiana, Lilium davidii* and *L. duchartrei.*

Another French missionary in China, active at about the same time (1862-75) was Jean Marie Delavay. Botany was merely a hobby for him, yet he managed to send home some 200,000 herbarium specimens of 4000 species. His territory was northwest Yunnan. Some of his more popular discoveries were *Primula malacoides, Aster delavayi, Incarvillea delavayi, Iris, delavayi* and the blue poppy *Meconopsis betonicifolia.*

During this period there were several important Russian plant explorers approaching China from the north through Mongolia, most notably Nicolai Przewalski and Grigori Potanin. Przewalski made four vain expeditions to reach Lhasa in Tibet and although he never attained his goal he collected some 1700 species from Kansu, Szechwan, northeast Tibet, Shansi and Mongolia including *Meconopsis integrifolia, Gentiana straminea* and *Lonicera syringantha.* Potanin's four expeditions concentrated on Mongolia, Tsinghai, Kansu, Szechwan and Shensi provinces and produced such fine plants as *Viburnum betulifolium, Larix potaninii* and *Gentiana hexaphylla.*

(To be continued.)

REFERENCES

Cox, E.H.M. 1945. Plant Hunting in China. Wm. Collins and Sons, London.

Farrer, R. 1917. On the Eaves of the World. Arnold and Co., London.

Healey, B.J. 1975. The Plant Hunters. Charles Scribner's Sons, New York.

Lemmon, K. 1968. The Golden Age of Plant Hunters. Phoenix House, London.

Wilson, E.H. 1930. Aristocrats of the Trees. The Stratford Co., Boston.

Announcements From the Unit Council

New officers of the Unit Council Governing Board elected to serve for the 1977 to 1979 term are: General Chairman, Mrs. Daniel Coleman (Sally Sue); 2nd Vice Chairman, Education, Mrs. Robert Arnold (Joan); Secretary, Mrs. James Andersen (Barbara); Assistant Secretary, Mrs. John Halloran (Darcy).

Over 100 enthusiastic members turned out on April 14th to weed and clean up beds in the Arboretum. A gentle rain the night before and a sunny day provided ideal weeding conditions. The annual Hat Parade at lunch time was a highlight of the day.

Gifts to the Arboretum from the Unit Council include $500 for a new portable electric soil sterilizer to be used by Mr. Richard van Klaveren in the Arboretum greenhouse, and $485 for new signs along the waterfront trail.

New Education Chairman, Joan Arnold, wishes to remind our readers that the Unit Council will again sponsor cutting parties during the summer. Material will be donated from outstanding gardens in the Seattle area.

She wishes also to suggest that, if sufficient interest is evinced by Foundation members, the Unit Council would be willing to sponsor a botany course next fall similar to that which was given last year by Dr. Janet Hohn. Call Joan at 232-8697 for further information.

RUTH MARY CLOSE

Notes and Comments

We regret the resignation of Mrs. Percy Guy who has served on the Editorial Board since 1972. Her strong and continuing interest in native plants has inspired many excellent articles in the *Bulletin*. In her place, however, we are very pleased to welcome Mrs. Page H. Ballard (Nan), who will undoubtedly lend vitality and sparkle to an already innovative board.

Arbor Day Plantings

April 13, 1977, Arbor Day, was the occasion of a tree planting ceremony on the new Union Bay Teaching and Research Arboretum site. At a luncheon prior to the ceremony, officers and members of the Arboretum Foundation, the Northwest Ornamental Horticultural Society, the University administration and the College of Forest Resources were given a status report on the development.

Mr. N. Stewart Rogers, president of the Foundation, and Mrs. Stephen Herron, president of the N.O.H.S., then symbolically planted the first tree in the new Arboretum, a handsome bald cypress, *Taxodium distichum*. Twelve other specimens were included in the Arbor Day planting, trees which will serve as test material to help determine how best to handle plants in this unusual situation.

*Lux Sit**

Visitors to the Arboretum office may have noticed the new lighting system recently installed. The original incandescent lamps have been replaced with energy efficient fluorescent fixtures. This will not only lower our electric bills, but has improved the lighting in the entire building. Funds for this work came from the University's Life and Fire Code budget since an inspection last fall revealed that the old wiring and lighting system was no longer safe and might cause a fire.

**Lux Sit* (Let there be light) is the motto of the University of Washington.

Is there a drought?

Despite March's welcome rainfall and increased snowpack, the miserly month of April has taken its toll.

By May 1st, the Skagit River basin had lost a good deal of its snowpack, and (as of this writing, in mid-May) Seattle City Light expects its Ross Lake reservoir in the North Cascades to be filled to only three-quarters of its capacity this year. Hydroelectric power, dependent on these resources, is therefore in short supply. City Light has been forced to purchase far more outside electricity than usual and has requested an electrical surcharge.

(Puget Power, which services the east side of Lake Washington, doesn't share City Light's problem since its reservoirs — Shannon and Baker Lakes — receive meltwater from glaciers on Mt. Baker and Mt. Shuksan as well as snowpacks from Swift Creek and Baker River valleys.)

Why, then, does the Seattle Water Department say there is no water shortage?

Seattle's water supply originates from a different source — the Cedar watershed near Snoqualmie Pass and the Tolt near Stevens Pass. Their location has afforded them enough rainfall to keep the Tolt River reservoir overflowing and the Cedar River reservoir about 89 percent full. The actual flow of the Cedar is about 50 to 60 percent of its normal rate but because the Water Department diverts only 20 to 25 percent of the water, no strain is felt on our supply.

Nevertheless, the nearby drought in Eastern Washington and the well-publicized and long-standing one in California are making some people worry about the future.

The Arboretum, for one, has taken some precautionary steps. Planting was cut in half this year and was completed earlier than usual. Transplanting was reduced, especially of large plants. About 10 percent more mulch was applied to the beds.

According to Patricia Gutter, of the Department of Landscape Architecture at the University of Washington, the western half of our state cannot afford to remain an isolated "pocket" where water is considered a cheap resource. There is always the threat of drier years ahead or of the eventual necessity of sharing our water with other parts of the United States. Professor Gutter, who recently attended a conference, "Drought and the Home Garden," sponsored by the University of California at Davis, believes California's water rationing should serve as a warning; she urged that we prepare for a water shortage, thus hopefully averting one.

The place to begin, she pointed out, is by understanding the basic horticultural requirements of plants in a particular garden — the optimum amount of water, sun, the type of soil and the root system.

Deep root systems require less water than shallow ones, she explained. One way to encourage this is with a method called "drip irrigation" in which plastic pipes deliver water, a drop at a time, to the soil. It can save from 25 to 50 percent of the water used in other common irrigation techniques.

Instead of "landscape-design" in the European tradition of verdant lawns and water-loving introductions, Gutter favors "conservation-design" where "form follows function." We need to be highly selective of plant material, she continued, by choosing natives and plants which can withstand dry climates.

If the nursery business is any indication, Professor Gutter may have a lot of convincing to do. Asked if sales had fallen off because of the threat of drought this summer, an employee of a large garden center near Seattle replied, "If you could see these customers!"

NANCY WALZ

The Arboretum Foundation Plant Sale on May 4th and 5th was once more an unqualified success. The rain, which had threatened during the early part of the week, held off during the hours of the sale. In the afternoon on Wednesday, eager crowds stood waiting for the gates to open. Early figures indicate a gross profit of over $36,000. It is expected the sale will net more than 45% of this, most of which is earmarked for use in the Arboretum. A final report will appear in the next issue of the *Bulletin*.

Book Reviews

HORTUS THIRD, A CONCISE DICTIONARY OF PLANTS CULTIVATED IN THE UNITED STATES AND CANADA, by the staff of the L.H. Bailey Hortorium, Cornell University, Ithaca, N.Y. Macmillan Publishing Co. Inc., New York, and Collier Macmillan Publishers, London, 1976. Price $99.50.

This is a massive work both physically and in its extensive contents.

It is a single volume, 8 by 11 inches, containing 1290 pages, and weighs almost seven pounds, more than twice as much as its predecessor, *Hortus Second* of 1941. Production in two smaller volumes would certainly have been more convenient for users.

Included within its covers are descriptions of more than 3300 genera and 20,000 cultivated species of plants, together with a very large additional number of subspecies, varieties, forms and cultivars. These names are derived from a card catalogue maintained at the Bailey Hortorium for more than 40 years, extracted from catalogues and seed lists obtained from nurseries, botanical gardens, arboreta and other sources. The area covered is continental North America north of Mexico, plus Puerto Rico and Hawaii.

Listing is alphabetical by genera, beginning with *Abelia* and concluding with *Zygosepalum,* arranged in double-column format on each page. Boldface capitals are used for generic names, boldface Roman type for species and other recognized names of all categories, making it easier to pick them out. Common names are printed in small capitals for contrast. Specific names are capitalized for the names of persons, for old generic names, etc. Commonly used synonyms are quoted and cross-referenced to their correct names. Subject headings are inserted at the head of each column.

While the staff of the Hortorium under Director Dr. David M. Bates was primarily responsible for the work, many other persons contributed to it because of their especial knowledge of certain families or genera; they are acknowledged in the preface but not indicated in the particular articles.

There are no keys for identification of species; each genus has a short botanical description as do the species or hybrids belonging to it. Small drawings of plants or flower parts of many of the chief families have been included, generally taken from other publications. In a few large genera such as *Iris, Narcissus, Rhododendron, Saxifraga* and *Sedum* subdivisions of the genus are briefly described, but in others, for example *Acer, Lilium, Penstemon, Pinus* and *Rosa,* this information is omitted.

The country or area of origin and sometimes the hardiness zone (U.S.D.A., 1960) to which the plant can be assigned is noted. The latter, however, is cited only "when known with reasonable certainty" and many important garden plants lack such information, for example the lavenders, rosemary and sweet bay *(Laurus nobilis).*

Notes on cultivation and propagation are frequently added following the generic descriptions, while plants of commercial value such as avocadoes, grapes, olives and onions also have cultivation details included. Subjects of some of the 187 separate articles are bulbs, conifers, ferns and fern allies, grafting (with an excellent full page illustration showing different methods), orchids, roses and soils.

The work concludes with: (a) a 20-page list of almost 3300 botanical authors cited, giving their full names and years of birth and death, a most useful reference list; (b) a glossary of botanical terms, covering 17 pages including one and one-half pages of illustrations; (c) a comprehensive and valuable index of more than 10,000 common names of plants, likely to be frequently consulted since few similar and accessible up-to-date lists exist. The end-papers provide newly redrawn Plant Hardiness Zones maps from the 1960 U.S.D.A. original.

The gathering and assembling of all this vast amount of accurate horticultural information obviously represents an enormous task by the director and staff of the Bailey Hortorium and their collaborators. It is little wonder that it has taken so long to accomplish. Innumerable users of this tome will be grateful for many years to come.

Nevertheless, the fact that it is all in one heavy volume, that there are no keys to distinguish one species from another, as have been done in at least some of the more important genera in the R.H.S. *Dictionary of Gardening,* and that the cost is so high, will all be likely to limit its sale. We hope, however, that it will be purchased and available in most public libraries especially for its extensive scope and the reliability of its nomenclature and descriptions.

BRIAN O. MULLIGAN

GROUND COVER AND OTHER WAYS TO WEED-FREE GARDENS, by Frederick A. Boddy. David & Charles, Publisher, Newton Abbot, London & Vancouver, 1974. Price 3.50 pounds in United Kingdom.

The lengthy title "Ground Cover and other ways to Weed-Free Gardens" which Frederick A. Boddy has chosen for his handbook, gives some inkling of the wide ranging discussion undertaken in its four separate sections. He has deemed it wise, in the first chapters, to acquaint us with various types of weeds, their habits of growth and particularly their root structures. Presumably one should then be better able to decide how to attack and eradicate these "rogues" or "gate crashers," as he terms them. Numerous excellent line drawings help identify the culprits, most of them quickly recognizable by genus, but often the European species mentioned is foreign to my vocabulary. A chapter on invasive plants calls attention to some which should be avoided even though they do not fall into the category of weeds.

The second section emphasizes the prevention of the intrusion of weeds. The brief paragraphs on specific parts of the garden serve as a bridge to the third and largest division of the book. The latter deals with ground covers by name, by description of each plant with the purpose it serves and the best way to handle it, and by excellent black and white photographs of actual plantings. My quarrel with the last chapter in this section is that genera only are listed and a great deal of reference must be made to the previous text to determine which species is intended. Granted that the excellent index helps with this task, yet I am not sure that many people would follow through to its conclusion.

The battle plan against weeds fills the final chapters. Weed control by manual means and by chemical treatment rate a chapter each but the latter, by Mr. Boddy's

own admission, contains material which is quickly outdated. It seems untrustworthy for us, particularly in view of controls which have been established, to follow more than the general words of caution about adhering to manufacturers' instructions, for both safety and success.

Some of the charm of this book stems from the use of common words in uncommon ways. A plant "consolidates itself" or "has not complained of a wet foothold" or its "image becomes tarnished." "Ground coverer" points up the usefulness of these low plants.

Naturally a professional gardener from another part of the world mentions many plants not in use here so the investigation of the suggestions made becomes an enlightening experience.

Despite the emphasis on self-maintenance in the garden, there is much call for "trimming to the base each year" and similar work. One cannot escape!

Mr. Boddy gives us a new look at the weed problem, describes his methods of attack and holds out the vision of a weed-free garden as the proverbial carrot is dangled in front of a rabbit.

FRANCES KINNE ROBERSON

Publications Chairman, Mrs. Harry Slater, wishes to call attention to the following items. Foundation members receive a 10 percent discount on all books purchased through this committee. Call Mrs. Slater at 232-0456.

A FIELD GUIDE TO PACIFIC STATES WILDFLOWERS, by Theodore F. Niehaus and Charles L. Ripper. Peterson Field Guide Series. Houghton Mifflin Co., Boston, 1976. Color and black and white illustrations. Price $10.95.
Arranged by color with a key to the families.

MOUNTAIN FLOWERS IN COLOR, by Anthony Huxley. Macmillan Publishing Co. Inc., New York, 1967. Color and black and white illustrations. Price $5.95.
The mountain flowers of Europe, arranged by family. Available once more.

GARDENING WITH HERBS FOR FLAVOR AND FRAGRANCE, by Helen Morgenthau Fox. Dover edition, unabridged and unaltered republication of 1933 edition (paperback). Price $3.00.

BRITISH COLUMBIA PROVINCIAL MUSEUM PUBLICATIONS:

Occasional Paper Series (paperback, 8½ by 11 inches)
#18 *CATKIN BEARING PLANTS OF BRITISH COLUMBIA,* by T. Christopher Brayshaw. 1976. Illustrated with botanical drawings. Price $3.00.

Handbooks (paperback, 5 by 7 inches)
#11 *THE MAMMALS OF BRITISH COLUMBIA,* by I.McT. Cowan and C.J. Guiguet. Sixth printing, last revised 1965. Black and white illustrations. Price $2.00.

#24 *GUIDE TO COMMON MUSHROOMS OF BRITISH COLUMBIA,* by R.J. Bandoni and A.F. Szczawinski. Fifth printing, major revision 1976. Color illustrations. Price $5.00.

#34 *FOOD PLANTS OF BRITISH COLUMBIA INDIANS, PART 1, COASTAL PEOPLES,* by Nancy J. Turner. 1975. Color and black and white illustrations. Price $4.00.

University of Washington Classes

Arboretum courses are not offered in the summer, but will continue in autumn quarter. Continuing Education is offering the following classes, however, which may be of special interest to *Arboretum Bulletin* readers. Complete information about these and many more noncredit courses is published in *Spectrum,* complimentary quarterly journal of Continuing Education. Call 543-2590 to place your name on the mailing list.

EXPLORING SEATTLE. A series of field trips by bus to explore Seattle's natural and man-made environments and their ecological effects. Wednesdays, June 29-August 10; 7-9:45 p.m.; 7 sessions.

GEOLOGY AROUND TOWN. Rock and mineral identification through field trips to see the many striking examples in outcrops, fossils, and decorative building facades. Thursdays, June 30-August 4; 7-9 p.m.; 6 sessions.

SUMMER SCIENCE WORKSHOP. A workshop for children interested in science who are entering 4th, 5th, or 6th grades in the fall. Tuesdays-Wednesdays-Thursdays, June 28-August 4; 9:30-11:30 a.m.; 18 sessions.

New Members of the Arboretum Foundation

We are pleased to welcome the following new members (January 19, 1977 through April 15, 1977):

Contributing – Ms. Shana Weeks. *Sustaining* – Mrs. Anne R. Conn, Mrs. Robert D. Davis, Mr. and Mrs. Herbert L. Meier, Mrs. M.P. Nichols, H.E. Olsson, Northwest Ornamental Horticultural Society, Oak Harbor Garden Club, Strybling Arboretum Society. *Annual* – Mrs. R.A. Adolphson, Mrs. Frank Amoto, Mrs. Bruce Amy, Mrs. Sally Anderson, Dr. and Mrs. T.M. Ballard, Mrs. Harley Beard, Mrs. K.B. Blaisdell, Mrs. Frances H. Bracher, Mr. Will Britt, Mrs. Patricia Brook, Mrs. John Cannon, Mrs. Richard Coronado, Mabelan Correa, Mrs. M.M. Davidson, Mrs. Clara F. Davison, Mrs. J.E. Dawson, Mrs. Ginger Dunmire, Mrs. Aldeen M. Emick, Mrs. Charles R. Falk, Forest and Wildlife Service, Mrs. Greta Hackett, Mrs. David Hamp, Mrs. Henry Haugen, Mrs. George W. Hazen, Mrs. Stephen A. Heard, Mrs.. Pat Heiden, Mrs. Donald E. Hillman, Ms. Luanna Iverson, Mrs. W.W. Johnson, Mrs. Walter A. Keckich, Mrs. Alsea LaRose, Sherry Y. Lien, Gregory L.K. Longman, Mrs. Carl Lovsted, Mrs. William Maloney, Mrs. Barbara M. Marcouiller, Mrs. Dorothy N. Martin, Ms. Mary Masuen, Mrs. Eddie A. Maulton, Mrs. A. McCormic, Mrs. Deanne Meine, Mrs. John S. Miller, Mary Jane Monday, Mrs. Maureen Muscarnere, Mrs. Margaret D. Nickum, Mrs. James Norman, Mrs. Jackie Pendergrass, Mrs. Maynard L. Pennell, Mrs. Betty Peterson, Mrs. Dean Peterson, Mr. and Mrs. Hollis N. Phillips, Mrs. Audrey C. Podl, Mrs. Susan K. Powers, Dave Read, Mrs. Liz Rosenberg, Mr. and Mrs. R.T. Rudolph, Mrs. Kent Saltonstall, Mrs. Glenn M. Scervie, Mrs. Nicholas Schmitt, Jr., Mrs. Jeanette Semke, Mrs. David R. Serebun, Mrs. Stephen J. Seyl, Mrs. Mary Lynne Sirutis, Sharlene Smith, Mrs. Ed Smyth, Mrs. Robert G. Thompson, Betty Tonkin, Mrs. Richard L. Turner, Mrs. Sandra C. Tussing, University of Michigan (two memberships), Mrs. Rejina N. Vashitis, Mrs. Paul Von Minden, Mrs. Barbara B. Wagner, Mrs. Gale Wald, Mrs. Marsha Walter, Mrs. Richard B. Walters, Ella E. Walton, Mrs. Elizabeth Wieting, Mrs. Beverly B. Wold.

We are also grateful to the following who have increased their dues to: *Supporting* – Mr. and Mrs. John S. Robinson. *Contributing* – Mrs. Frank Hawkins, Dr. and Mrs. L.H. Pinkers, Mrs. C.E. Simons. *Sustaining* – Mrs. Stephen M. Bannick, Mrs. John M. Baxter, Mrs. Daniel H. Cahill, Mrs. J.R. Combs, Mrs. Irene C. Fram, Mrs. Roger W. Jones, Mrs. George Morry, Mrs. R. Floyd Reynolds, Mrs. John H. Robertson, Sara Schanen, Karl I. Sifferman, Mr. and Mrs. William Yorozu.

Asplenium trichomones
Drawing: Mareen Kruckeberg

The Northwest Ornamental Horticultural Society will sponsor its annual fern sale on Wednesday, June 15 from 10 a.m. to 6 p.m. in the Bellevue Square, Bellevue.

CHOICE and UNUSUAL
Trees — Shrubs — Vines
Garden Accessories
TROPICAL INDOOR PLANTS
Largest & Finest Selection
In the Entire Northwest

Cut Flowers
Potted Plants and Gifts
COMPLETE FLORAL SERVICE

LAND OF FLOWERS

9701 - 15th N.W. — Phone SU 2-2544
Producers of Fine Plants Since 1888

Back Issues of
the ARBORETUM BULLETIN
dating prior to 1975

are now for sale, when available, for 25¢ per individual copy.

Bargain packages of issues in large supply are made up in several series of 10 numbers for $1.00 (plus mailing and handling charges unless purchased at the Foundation office).

For further information, call

Mrs. Harry Slater

232-0456

Compliments of

FRAYN
PRINTING COMPANY

LETTERPRESS • LITHOGRAPHY • STEEL DIE ENGRAVING
2518 WESTERN AVENUE • SEATTLE, WASHINGTON 98121/(206) 623-4221

For GIFTS and FLOWERS
of Unmistakable Distinction

Crissey
FLOWERS • GIFTS
622-1100

1335 Fourth Avenue — Washington Building
2100 Fifth Avenue at Lenora

THE ARBORETUM BULLETIN

Published by the
Arboretum Foundation
University of Washington Arboretum
Seattle, Washington 98195

MRS. H. P. CLAUSING
13002 N.E. 3RD
BELLEVUE, WA 98005

NON-PROFIT ORG.
U. S. POSTAGE PAID
SEATTLE, WASHINGTON
Permit No. 126

ADDRESS CORRECTION REQUESTED

Photo: Brian O. Mulligan

***Carpenteria californica* blooming in late June.**

VISIT YOUR ARBORETUM IN SUMMER

Enjoy the peace of the Japanese Garden.

Follow the Waterfront Trail from Foster's Island.

See the summer-blooming trees and shrubs on Arboretum Drive.

Join the Explorers' Walk on June 22, July 27 and August 24, meeting at 10 a.m. in the parking lot of the administration buildings.